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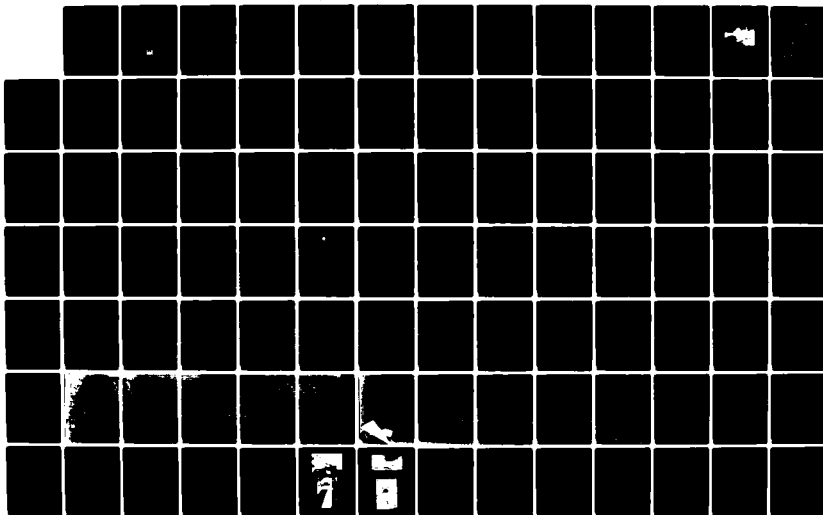
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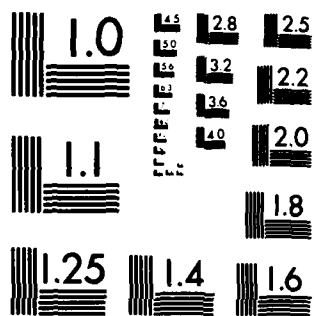
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BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS

GREEN HILL POND DAM
MA 00149

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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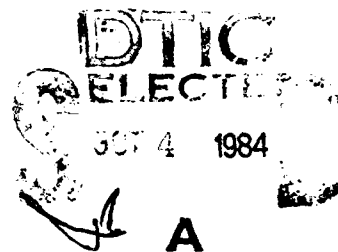


DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Green Hill Pond Dam is an earthfill embankment 200 feet long and 20 feet high with a stone masonry core wall 17 feet high. Generally the dam is in good condition although the outlets to the spillway and overflow diversion are in poor condition. Green Hill has been classified in the "high" hazard category. There is potential hazard at the site. An inflow test flood of 280 cfs will overtop the main dam by an average of 0.2 feet.		

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GREEN HILL POND DAM

MA 00149

BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
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NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00149

Name of Dam: Green Hill Pond

Town: Worcester

County and State: Worcester County, Massachusetts

Stream: Hermitage Brook - Tributary of the Blackstone
River

Date of Inspection: July 31, 1978

Green Hill Pond Dam, which was originally built around 1850, was reconstructed about 1881. The dam is an earthfill embankment 200 feet long and 20 feet high with a stone masonry core wall 17 feet high. The spillway is an ungated overflow weir with a vertical discharge shaft which is located near the midpoint of the dam. The weir is 23.6 feet long with an elevation (El) of 651.0 at the crest. The ungated outlet conduit from the spillway is 573 feet long. It consists of an 18-inch diameter reinforced concrete pipe which connects to a 30-inch diameter reinforced concrete pipe. There is an overflow diversion structure located at the northeast end of the pond. The outlet conduit for the overflow is 30-inch diameter reinforced concrete pipe. The inlet to the diversion has an elevation of 650.9. Due to downstream pipe sizes and slopes, the overflow diversion could be inoperative during peak storms.

Green Hill Pond Dam was neither designed nor constructed according to current state-of-the-art procedures. There are areas of concern which must be corrected to assure the continued performance of this dam. This conclusion is based upon the visual inspection at the site, the limited engineering data, and limited evidence of operational and maintenance procedures. Generally,

the dam is in good condition although the outlets to the spillway and overflow diversion are in poor condition. Green Hill has been classified in the "high" hazard category.

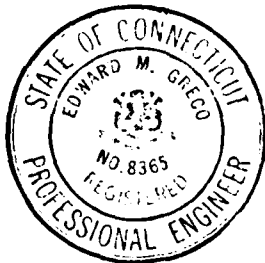
The following are visible signs of distress which indicate a potential hazard at the site: blockage of the shaft of the spillway, blockage of the overflow diversion, leakage through the walls of the spillway, misalignment of the stone block forming the western half of the spillway, siltation of the outlet conduit at 121 feet and 573 feet downstream of the dam, erosion and lack of riprap on the upstream face of the dam, erosion due to surface runoff on the downstream face of the dam, accumulation of surface runoff in the playground area at the toe of the dam, and erosion of the trash gate and the concrete on the intake box of the diversion conduit.

Hydraulic analyses indicate that the spillway at the dam can discharge a flow of 33 cfs at El 653 which is the average elevation of the crest of the dam. An inflow test flood of 280 cfs will overtop the main dam by an average of 0.2 feet. These calculations are based on an unobstructed flow through the spillway and do not consider overflow through the diversion. In the event of overtopping, complete failure of the dam is unlikely to occur. However, erosion of the dam could occur resulting in a breach and partial failure of the dam.

It is recommended that the Owner accomplish the following: remove debris from the shaft of the spillway and from the overflow diversion, install a trash rack on the spillway and repair the trash rack on the overflow diversion, construct an overflow spillway, construct a gated outlet, repair leakage and the misaligned slab at the weir of the spillway, clean accumulated silt out of the outlet conduit, repair erosion on the upstream face of the dam and protect the slope with riprap, construct a swale to prevent surface runoff from eroding the downstream face of the dam and collecting in the area at the toe of the dam, and repair the concrete on the intake of the diversion conduit. The Owner should also implement a systematic program of inspection and maintenance.

The debris in the spillway and in the overflow diversion should be removed within 30 days. The remaining recommendations and remedial measures outlined above and in Section 7 should be implemented

by the Owner within a period of 2 years after receipt of this Phase I Inspection Report. An alternative to these recommendations would be to drain the pond and breach or remove the dam.



A handwritten signature in cursive script, reading "Edward M. Greco".

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Approved by:

A handwritten signature in cursive script, reading "Stephen L. Bishop".

Stephen L. Bishop, P.E.
Vice President
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No. 19703



This Phase I Inspection Report on Green Hill Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials
Branch
Engineering Division

FRED J. Ravens, Jr., Member
Chief, Design Branch
Engineering Division

SAUL C. COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrology and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general conditions and the downstream damage potential.

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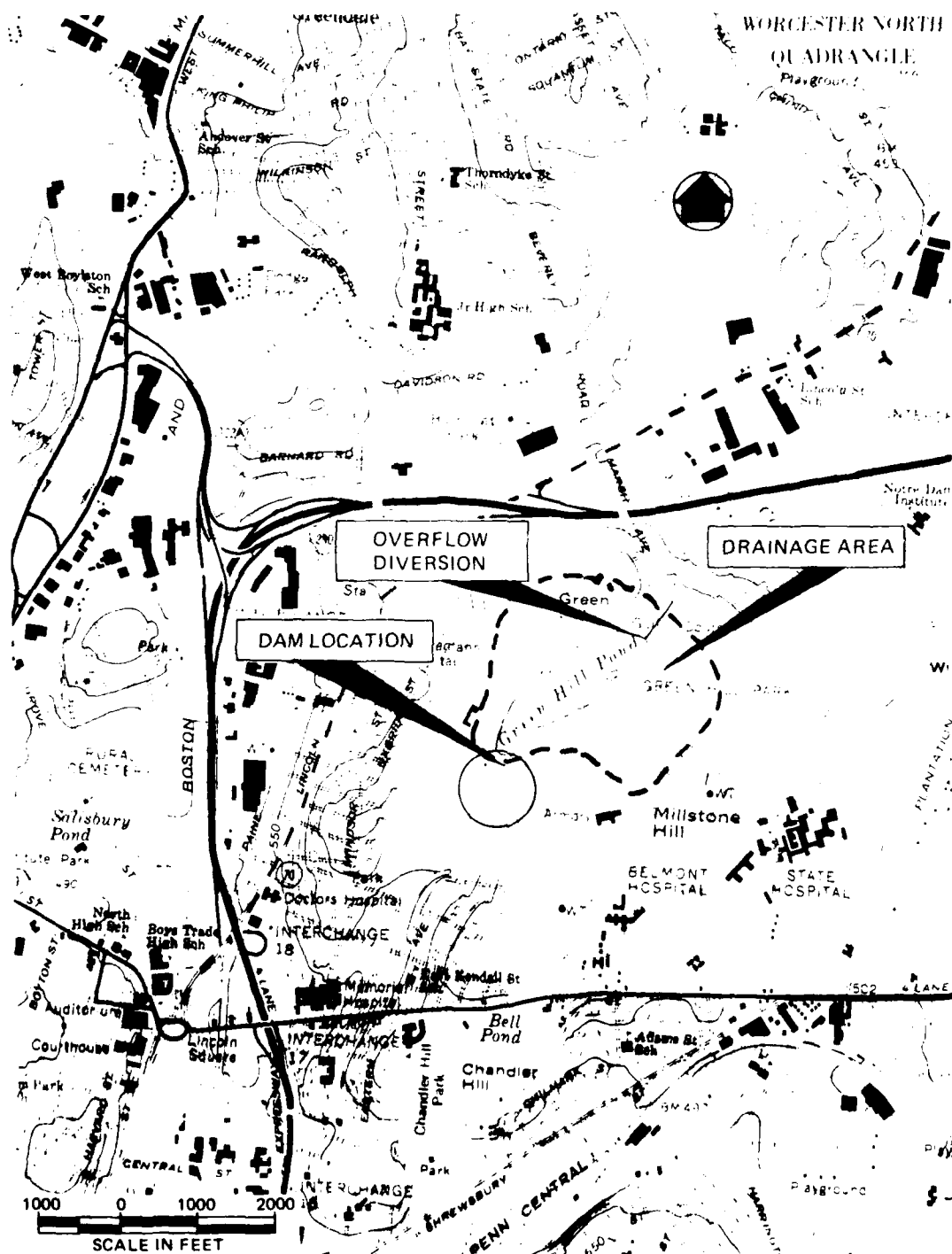
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**OVERVIEW
GREEN HILL POND
WORCESTER, MASSACHUSETTS**



VIEW FROM EAST ABUTMENT

**Location and Direction of Photographs
Shown on Figure in Appendix B**



LOCATION MAP - GREEN HILL POND

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

GREEN HILL POND

SECTION 1

PROJECT INFORMATION

1.1 General

- a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Metcalf & Eddy, Inc. under a letter of May 3, 1978, from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0306 has been assigned by the Corps of Engineers for this work.
- b. Purpose
 - (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
 - (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
 - (3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

- a. Location. The dam is located on the headwaters of Hermitage Brook, a tributary of the Blackstone River, in the City of Worcester, Worcester County, Massachusetts (see Location Map).
- b. Description of Dam and Appurtenances. Green Hill Pond dam is an earth fill dam about 200 feet long with a maximum height of 20 feet (see Plan of Dam and Sections, Figures B-1 and B-2). The embankment is founded on bed-rock and is constructed of a stone masonry core wall 5 feet thick at the bottom, 2 feet thick at the top, and 17 feet high (see Figure B-4). The remainder of the embankment is earth fill. The crest of the dam is generally about 30 feet wide but increases to about 100 feet wide at the west abutment. The elevation (El) of the crest varies from 652.5 to 654.0. A paved road, Green Hill Parkway, is located on the crest. The upstream slope is 7:1 and is a sandy beach. The downstream slope is 5:1 and is covered with grass.

A vertical shaft spillway is located near the midpoint of the dam. It consists of a 23.6 feet long (side to side) granite overflow weir and a 3.6 by 25.6 foot (inside dimensions) vertical stone shaft with 2.7 foot thick walls. The crest of the spillway is at El 651.0. The shaft descends about 17.4 feet to an invert at El 633.6 and connects with the outlet conduit which is perpendicular to the dam (see Figure B-3). A stone headwall which was part of the original dam may still be located below the ground surface downstream of the spillway (see Figure B-4).

Water over the spillway discharges about 573 feet downstream of the upstream face of the dam. Manholes are located 121 feet, 306 feet, and 424 feet along the outlet conduit from the spillway (see Figure B-2). At the upstream end of the first manhole, the conduit is 18-inch diameter reinforced concrete pipe. From the downstream end of the first manhole to the

outlet, the conduit is 30-inch diameter reinforced concrete pipe. The size of the outlet from the spillway to the 18-inch diameter pipe is unknown. Drawings (Figures B-3 and B-4) indicate that there is a 38-foot-long approach channel on the bottom of the pond which leads to a 1.3-foot-wide by 4.5-foot-high opening at the base of the stone shaft of the spillway. This opening leads to a box conduit which passes beneath the shaft and the wall of the old dam and enters a 3.8-foot-wide by 7-foot-high stone horseshoe-shaped tunnel. The transition from this old conduit to the 18-inch diameter reinforced concrete pipe is unknown. The invert of the 18-inch pipe is at El 636.6 at the first manhole. The invert of the 30-inch pipe is El 633.0 at the outlet.

An overflow diversion structure is located at the northeast end of Green Hill Pond (See Location Map). Flow from this diversion is to Coal Mine Brook, about 0.4 miles to the northeast (see Figure B-5). The diversion conduit is a 30-inch diameter concrete pipe which leads to a 48-inch diameter tunnel beneath Green Hill, discharging to various smaller pipes downstream. The inlet to the conduit is a concrete box with a 1.6-foot-high by 12-foot-long opening on the upstream face. The overflow weir to the conduit is at El 650.9.

- c. Size Classification. Green Hill Pond Dam is classified in the "small" category since it has a maximum height of 20 feet and a maximum storage capacity of 300 acre-feet.
- d. Hazard Classification. Immediately downstream of the dam is a public park and playground. Thickly developed commercial and residential areas of Worcester are located in the downstream valley about 0.3 miles from the dam. Memorial Hospital is also located 0.7 miles downstream in the valley. In the event of dam failure, more than a few lives could be lost and extensive property damage could occur.

A 12-foot-high, abandoned dam located 1,300 feet below Green Hill Pond may impede some flood flows. However, the condition and stability of that dam is unknown. Accordingly, Green Hill Pond Dam has been classified in the "high" hazard category. A 1973 inspection report by the Massachusetts Department of Public Works indicates there is no risk to life and property.

- e. Ownership. The dam is presently owned by the Worcester Department of Public Works, 30 E. Worcester Street, Worcester, Massachusetts 01604. Mr. F. Worth Landers, Commissioner (617-798-8151) granted permission to enter the property and inspect the dam.
- f. Operator. There are no known operators of the dam since there are no operational features.
- g. Purpose of Dam. The dam was originally constructed by the Green family at their estate for recreational and aesthetic purposes. In about 1905, the estate was given to the City of Worcester. The pond was used for swimming until about 1951. After that time records indicate the water became polluted from the cesspool for the bathhouse and from livestock grazed nearby. Since 1955, the pond has not been suitable for swimming. The adjoining land is utilized for a playground, picnic area, and a golf course.
- h. Design and Construction History. The original dam, shown on the 1881 drawings as the "old dam" (see Figure B-3), was probably built around 1850 and is presumably still in place below the ground surface. Drawings indicate it consists of a 14.5 foot high, 10.5 foot thick vertical stone wall with an outlet conduit at the base which lead to a 3.8 foot wide by 7 foot high (inside dimensions) stone horseshoe-shaped tunnel (see Figures B-3 and B-4).

About 1881, Martin Green designed changes to the dam which presumably were built a short time later. These changes included construction of the vertical shaft spillway, reconstruction of the embankment with a stone core

wall, and extension of the outlet conduit upstream, including a slide gate and an approach channel. About 1905, the dam and part of the Green family estate were given to the City of Worcester.

An inspection report written in 1938 stated that the slide gate to the outlet was broken and inoperable and a fish screen was on the spillway weir. After the 1936 floods, the overflow diversion was constructed by the City of Worcester. Also, some time between 1955 and 1965, the area below the toe of the dam was filled in to make a playground, and the outlet conduit was extended to its present location.

1. Normal Operational Procedures. There are no normal operating procedures at this dam. There is no apparent outlet control, and it appears that the approach to the outlet conduit is filled with sand. However, a flow of 5 to 10 gallons per minute is discharging from the downstream end of the conduit.

The spillway for Green Hill Pond is ungated and flows are unrestricted, although the vertical shaft is blocked with debris.

The overflow diversion is also uncontrolled, and the opening to the 30-inch conduit is filled with debris.

1.3 Pertinent Data

- a. Drainage Area. The approximately 136-acre (0.21 square mile) drainage area above the dam consists of a park and golf course. The land is sparsely developed, mostly grassed, and has moderate slopes. Discharge is to Hermitage Brook, which flows to a 12 foot high abandoned dam located about 1,300 feet downstream of Green Hill Pond. Some flow appears to enter a 2.6 foot high by 5.3 foot wide box conduit at the dam and could not be detected further downstream. Residential areas are situated 150 feet downstream of the abandoned dam, and the valley continues approximately along Hooper Street into downtown Worcester.

- b. Discharge at Dam Site. Water discharges from the pond through an 18-inch and a 30-inch diameter, reinforced concrete outlet conduit. Drawings indicate that flow into the conduit is through the 25.6-foot by 3.6-foot vertical shaft of the spillway and from a 1.3 foot by 4.5-foot slide gate opening at the bottom of the upstream wall of the shaft. Presently, debris is blocking the shaft, and sand has accumulated upstream of the gate opening. Both the spillway and the opening are uncontrolled. The outlet conduit discharges 573 feet downstream, at an invert elevation of 633.0. The lower 452 feet of conduit has a 0.2 to 1.3 percent slope.

The pond can also overflow through a 30-inch diameter diversion conduit located at the opposite end of the pond from the dam. The conduit has a 1.6-foot by 12-foot intake opening with an overflow elevation of 650.9. The conduit has a slope of about 0.4 percent.

Hydraulic analyses indicated that the spillway can discharge an estimated 33 cfs at El 653 which is an average elevation of the crest of the dam. An inflow test flood of 280 cfs (half of the probable maximum flood) will overtop the main dam by an average of 0.2 feet. These calculations do not take into consideration the discharge into the overflow diversion which is presently blocked with debris. Due to downstream pipe sizes and slopes, the overflow diversion could be inoperative during peak storms even after the debris is cleared.

The maximum flood at the dam site is unknown; but personnel at the Worcester Parks Department recall the dam being overtopped with flow over Green Hill Parkway.

- c. Elevation (feet above Mean Sea Level (MSL)). A benchmark at El 651.0 was established at the spillway crest. The elevation was estimated from a U.S.G.S. topographical map.

- (1) Top dam 652.5 to 654.0
- (2) Test flood pool: 653.2
- (3) Design surcharge (original design):
unknown
- (4) Full flood control pool: Not Applicable
(N/A)
- (5) Recreation pool: 650.9 overflow diversion
651.0 spillway crest
- (6) Spillway crest (ungated): 651.0
- (7) Upstream portal invert diversion tunnel:
650.9
- (8) Stream bed at centerline of dam: 633.9
- (9) Maximum tailwater: None

d. Reservoir

- (1) Length of maximum pool: 2,400 feet
- (2) Length of recreation pool: 2,400 feet
- (3) Length of flood control pool: N/A

e. Storage (acre feet)

- (1) Test flood surcharge: 60 at El 653.9
- (2) Top of dam: 300
- (3) Flood control pool: N/A
- (4) Recreation pool: 250 (Approximate)
- (5) Spillway Crest: 250

f. Reservoir Surface (acres)

- *(1) Top dam: 27
- *(2) Maximum pool: 27
- (3) Flood-control pool: N/A
- (4) Recreation pool: 27
- (5) Spillway crest: 27

g. Dam

- (1) Type - earthfill
- (2) Length - 200 feet
- (3) Height - maximum 20 feet
- (4) Top width: 30 to 100 feet
- (5) Side slopes - upstream 7:1; downstream 5:1
- (6) Zoning: Unknown
- (7) Impervious core: Stone masonry core wall
- (8) Cutoff: Unknown, bedrock foundation
- (9) Grout curtain: Unknown

1. Spillway

- (1) Type: overflow weir with vertical shaft
- (2) Length of weir: 23.6 feet
- (3) Crest elevation: 651 MSL (assumed benchmark)
- (4) Gates: None

*Based on the assumption that the surface area will not significantly increase with changes in reservoir elevation from 651.0 to 653.0.

(5) Upstream Channel: None

(6) Downstream Channel: 25.6 feet by 3.6 feet
vertical stone shaft to outlet conduit

- j. Regulating Outlets. The regulating outlet at the dam is an 18-inch and a 30-inch diameter reinforced concrete pipe which are ungated.

Discharge is presently flowing at 5 to 10 gpm from the downstream end of the pipe. The source of this flow is unknown, but could be from the shaft of the spillway and/or from the intake of the conduit. There is no apparent control of this outlet.

The pond level is also regulated by a side inlet box spillway which discharges to a 30-inch diameter diversion conduit located at the northeast end of the pond. This inlet is not controlled. The pond level is below the overflow level at the present time.

SECTION 2
ENGINEERING DATA

- 2.1 General. The only plans, specifications, or computations available from the Owner, State, or County offices relative to the design and construction of this dam are: two sheets of drawings dated May 10, 1881 showing the original dam and proposed reconstruction (copies in Appendix B); and three undated drawings for the overflow diversion (copy of Sheet No. 1 in Appendix B). The only other data available for this evaluation were visual observations made during inspection, review of a previous inspection report, and conversations with personnel at the Worcester Department of Public Works (Owner of the dam), the Worcester Parks Department, and State and County agencies.

We acknowledge the assistance and cooperation of personnel of the Massachusetts Department of Public Works: Messrs. Willis Regan and Raymond Rochford, and of the Massachusetts Department of Environmental Quality Engineering, Division of Waterways: Messrs. John J. Hannon and Joseph Iagallo.

Also, we acknowledge the cooperation and assistance of personnel from the Worcester County Engineer's Office: Messrs. John O'Toole, Joseph Brazauskas, and Mr. Wallace Lindquist - recently retired from county service.

In addition, we thank Mr. F.W. Landers, Commissioner, Worcester Department of Public Works, who allowed us to inspect the dam. We also thank Messrs. Richard Grant and Edward Mara of the Worcester Department of Public Works, and Tom Taylor of the Worcester Parks Department, each of whom researched their files for information on the dam.

- 2.2 Construction Records. There are no detailed construction records available.
- 2.3 Operation Records. No operation records are available, and there is no daily record kept of the elevation of the pool or rainfall at the dam site.
- 2.4 Evaluation
- a. Availability. Due to the age of this dam, there is limited engineering data available.
 - b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.
 - c. Validity. The limited engineering data available is valid.

SECTION 3
VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I Inspection of the dam at Green Hill Pond was performed on July 31, 1978. A copy of the inspection check list is included in Appendix A. Previous inspections of this dam have been made by others since 1938. A partial listing of these inspections is in Appendix B. An inspection was made in 1973 by personnel from the Massachusetts Department of Public Works. A copy of their report is included in Appendix B.
- b. Dam. Green Hill dam is an earth fill embankment with a stone masonry core wall. The dam is generally in good condition. No seepage was noted at the dam. The slopes of the dam are flat and clear of trees. The crest is mostly a paved roadway. Two signs of distress were observed at the site. First, erosion has occurred on the upstream face of the dam near the west abutment. Sand has been washed away around the concrete slabs in the picnic areas. The slabs are cracked and settled. There are no signs of riprap protection on the upstream face of the dam. Secondly, surface runoff from Green Hill Parkway, which collects near the midpoint of the dam, has eroded a gully in the downstream face. This runoff combines with runoff from the hillside east of the dam and forms large puddles of water in the playground area downstream of the toe of the dam.
- c. Appurtenant Structures. The spillway is a vertical stone shaft with a granite overflow weir. The structure is in poor condition. Water is flowing under the granite weir and into the shaft. The piece of granite on the west half of the weir is misaligned. The shaft is filled with soil and debris to within 2 feet of the crest of the weir. This obstruction restricts all flows over the spillway. There is a fence located upstream of the crest of the spillway.

The outlet conduit extends 573 feet from the upstream face of the shaft of the spillway to the outlet. The upstream approach area appears to be completely filled with sand. The condition of 121 feet of the conduit under the dam is unknown. Sediment has accumulated to a depth of 0.5 feet at the bottom of the first manhole located 121 feet downstream. The conduit appears to be blocked between the first and second manholes. The outlet end of the conduit contains a build-up of sediment 0.9 feet thick at the invert of the pipe.

The overflow diversion structure is located at the northeast end of the pond and has a concrete box intake with a trash rack. The conduit is completely blocked with leaves, trash, and other debris. This material passed through the 6-inch openings of the trash rack and through an opening on the top of the intake box. The trash rack is severely corroded. Erosion of the concrete has also taken place on the upstream face of the intake box.

- d. Reservoir Area. The area around Green Hill Pond is a park and golf course. There are a few buildings, such as a club house and maintenance buildings, but no residences. It is unlikely that significant development will occur in the future. The area is grassed and wooded and has moderate slopes of 10 to 20 percent.
- e. Downstream Channel. Discharge from the outlet flows about 700 feet downstream in a natural stream bed which slopes at about 2 percent. At that point, water enters a 5.3-foot-wide by 2.6-foot-high concrete box conduit which is part of a 12 foot high abandoned dam. The outlet to the conduit was not visible. Flow may continue downstream in the natural stream bed. The valley continues at a slope of 3 percent into residential and commercial areas of downtown Worcester.

3.2 Evaluation. Although the dam appears to be in good condition, the two outlets of the dam are blocked and the outlet conduit from the spillway is partially filled with silt. It is evident that these structures are not adequately maintained. Recommended measures to improve these conditions are stated in Section 7.3.

SECTION 4
OPERATIONAL PROCEDURES

- 4.1 Procedures. There are no operational procedures at this dam.
- 4.2 Maintenance of Dam. An office of the Worcester Parks Department is located near the dam. However, the outlets for the dam are not adequately maintained. Some maintenance to the dam has occurred since the spring, such as repair of erosion from surface runoff on the downstream face of the dam and around the stone wall of the spillway. However, the spillway, the outlet conduit, and the diversion conduit are all blocked with debris. The 1973 inspection report prepared by the Massachusetts Department of Public Works (see copy in Appendix B) recommended that debris be cleared from the spillway.
- 4.3 Maintenance of Operational Facilities. Only the downstream end of the outlet conduit was visible during inspection. The end of the pipe is filled in with silt to a depth of 0.9 feet. The condition of the intake was not visible, since it is apparently plugged. The overflow diversion is plugged with leaves, wood, and trash.
- 4.4 Description of Any Warning Systems in Effect. There are no warning systems in effect at this dam.
- 4.5 Evaluation. There are no operational or warning systems in effect at Green Hill Dam, and the maintenance is inadequate. This is extremely undesirable, considering the dam is in the "high" hazard category. A program of operation and maintenance for this dam should be implemented as recommended in Section 7.3.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design Data. The probable maximum flood (PMF) rate was determined to be 2,650 cfs per square mile. This calculation is based on an average drainage area slope of 11 percent, the pond-plus-swamp area to drainage area ratio of 23.8 percent, and the U.S. Army Corps of Engineers' Flow Rates (dated December 1977). Applying one-half the PMF to the 0.21 square miles of drainage area results in a calculated peak flow of 280 cfs as the inflow test flood. By adjusting the inflow test flood for surcharge storage, the maximum discharge at the spillway was established as 92 cfs with a water surface at El 653.2.

An overflow diversion structure at the northeast end of Green Hill Pond was not included in these calculations. The structure consists of a 30-inch diameter pipe having an overflow at El 650.9. Outflow from Green Hill Pond would be through this structure before discharging over the spillway. However, because the pipe was obstructed with debris, it is inoperative. Furthermore, due to downstream pipe sizes and slopes, the overflow diversion could be inoperative during peak storms, even after the debris is cleared. All calculations are therefore based on the overflow diversion being inoperable.

Flow over the crest of the dam is predicted to be 58 cfs while flow over the main spillway would be 34 cfs. The discharge over the spillway is controlled by the 18-inch outlet pipe downstream of the spillway. The maximum head on the dam would be 0.7 feet with a discharge of 1.5 cfs per foot of width. The depth of water over the dam at critical flow would be at 0.4 feet with a velocity of 3.6 fps.

- b. Experience Data. Hydraulic records are not available for this dam. Personnel at the Green

Hill office of the Worcester Parks Department recall that in 1955 the dam was overtopped and that flow was over Green Hill Parkway.

- c. Visual Observations. Normal discharge from Green Hill Pond is over the main spillway and through an overflow diversion structure at the northeast end of Green Hill Pond. The flow over the spillway before overtopping is controlled by an 18-inch pipe. The overflow diversion structure upstream was partially filled with leaves, silt, and debris and discharge was totally restricted. The trash rack was severely corroded.
- d. Overtopping Potential. Overtopping of the dam is expected under the inflow test flood of 280 cfs. Discussion with Personnel from the Worcester Parks Department indicated that the dam was overtopped during the 1955 flood. In the event of overtopping, complete failure of the dam is unlikely to occur. However, erosion of the dam could occur resulting in a breach or partial failure of the dam.

A flood wave due to dam failure would have a height of 4.0 feet at a velocity of 14 fps.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual Observations. The evaluation of the structural stability of Green Hill Pond Dam is based on the visual inspection conducted on July 31, 1978. As discussed in Section 3, Visual Inspection, the embankment of the dam is generally in good condition, although the shaft of the spillway, the outlet conduit, and the diversion conduit are blocked.

Based on these observations the embankment of the dam is not a potential hazard, however, blockage of the spillway and the overflow diversion is a serious hazard.

- b. Design and Construction Data. There are two drawings dated 1881 available from the County on the design and construction of this dam (see Figures B-3 and B-4). There are also three drawings available from the City on the design and construction of the diversion conduit (Sheet No. 1 is included as Figure B-5). There are no other plans, specifications or computations available on the design, construction, or repair of this dam from the Owner, County, or State officers. Furthermore, information does not appear to exist on the type, shear strength, and permeability of the soil and/or rock materials of the embankment.

Green Hill Pond Dam was originally built about 1850 and was reconstructed about 1881. Drawings indicate the embankment contains a 17-foot- high, tapered stone masonry core wall, 5 feet thick at the base and 2 feet thick at the top (see Figure B-4). The remainder of the embankment is earth fill. The dam is shown on the drawings to be founded on bedrock.

- c. Operating Records. There is no evidence of instrumentation of any type in Green Hill Pond Dam, and there is nothing to indicate that any instrumentation was ever installed in this dam. The performance of this dam under prior loading can only be inferred by physical evidence at the site.
- d. Post-Construction Changes. There are no as-built drawings available for Green Hill Pond Dam. The drawings dated 1881 show some of the original 1850 dam. The outlet of the conduit was extended from a point 75.5 feet downstream to a point 573 feet downstream. The location and type of transition from the old outlet conduit under the dam to the 18-inch outlet pipe is unknown.

An overflow diversion structure was also constructed at the northeast end of the pond. This was probably built sometime after the 1936 storms.

- e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with Phase I "Recommended Guidelines" does not warrant seismic analyses.

SECTION 7
ASSESSMENT, RECOMMENDATIONS,
AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition. Green Hill Pond Dam was neither designed nor constructed according to current state-of-the-art procedures. Based upon the visual inspection of the site, the limited engineering data and a lack of operational or maintenance information, there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the dam is considered to be in good condition although the outlets to the spillway and overflow diversion structure are in poor condition. Several signs of distress were observed at the site: blockage of the shaft of the spillway and the diversion conduit; leakage through the walls of the spillway; misalignment of the stone block forming the western half of the spillway weir; silt deposited in the outlet conduit at the upstream manhole and at the downstream end; erosion and lack of riprap on the upstream face of the dam; erosion due to surface runoff on the downstream face of the dam; poor drainage of the playground area at the toe of the dam; and corrosion of the trash rack and spalling of the concrete intake on the diversion conduit.

Hydraulic analyses indicate that the spillway can discharge a flow of 33 cfs at El 653 which is an average elevation of the crest of the dam. An inflow test flood at 280 cfs (half of the probable maximum flood) will overtop the dam by an average of 0.2 feet. This calculation is based on an unobstructed flow into the spillway, which is presently blocked, and does not consider discharge through the overflow diversion which is blocked and may be inoperative during peak flows. Previous experience indicates the dam was overtopped in the 1955 floods.

- b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.
- c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within 2 years after receipt of this Phase I Inspection Report. However, clearing of the debris from the spillway and from the overflow diversion facilities should be done within 30 days.
- d. Need for Additional information. Additional investigations to further assess the adequacy of the dam are outlined below in Section 7.2. Recommendations.

7.2 Recommendations. In view of the concerns over the continued performance of the dam and spillway, it is recommended that the Owner employ a qualified consultant to:

- a. conduct a more detailed field investigation of the spillway outlet and the overflow system.
- b. conduct a more detailed hydrologic and hydraulic investigation of the spillway and overflow diversion.

The recommendations on repairs and maintenance procedures are outlined below under Section 7.3, Remedial Measures.

7.3 Remedial Measures

- a. Alternatives. An alternative to implementing the recommendations listed above and the maintenance procedures itemized below would be to drain the pond and breach or remove the dam.
- b. Operating and Maintenance Procedures. The dam and appurtenant structures are not adequately maintained. It is recommended that the Owner accomplish the following:

- (1) remove all debris from the shaft of the spillway and the overflow diversion facilities
- (2) install a trash rack on the spillway and repair the trash rack on the overflow diversion
- (3) construct a gated outlet
- (4) repair the weir of the spillway where water is flowing beneath the granite slabs and realign the western weir stone.
- (5) clean accumulated silt out of the man-holes and outlet conduits
- (6) repair erosion on the upstream face of the dam and protect the slope with riprap
- (7) construct a swale along Green Hill Parkway such that surface runoff does not erode the downstream face of the dam and collect in the area of the toe of the dam
- (8) construct a swale such that surface runoff from the downstream side slopes does not collect and form wet areas below the toe of the dam
- (9) repair the concrete on the intake of the diversion conduit
- (10) implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances, supplemented by additional inspections during and after severe storms. The spillway and the overflow diversion should be examined at that time. All repairs and maintenance should be undertaken in accordance with all applicable State regulations
- (11) periodic technical inspections of this dam should be continued on a bi-annual frequency

- (12) institute a definite plan for surveillance and a warning system during periods of unusually heavy rains and/or runoff.

APPENDIX A
PERIODIC INSPECTION CHECKLIST

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Green Hill Pond

DATE 7/31/78

TIME 8:00 AM - 1:00 PM

WEATHER partly cloudy - 75°F

W.S. ELEV. 650.3 ^{*} U.S. 633.9 DN.S.

* assumed benchmark elevation 651.0
on top of spillway weir - from USGS
topographic quadrangle

PARTY:

- | | |
|-------------------------|-----------------------|
| 1. <u>Mike Larson</u> | 6. _____ |
| 2. <u>Ed Greco</u> | 7. <u>Sue Pierce</u> |
| 3. <u>Lyle Branagan</u> | 8. <u>Lou Taverna</u> |
| 4. <u>Dick Weber</u> | 9. <u>David Cole</u> |
| 5. <u>Carol Sweet</u> | 10. _____ |

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>dam embankment</u>	<u>Larson + Greco</u>	
2. <u>spillway</u>	<u>Branagan</u>	
3. <u>outlet conduit</u>	<u>Branagan + Larson</u>	
4. <u>diversion conduit</u>	<u>Larson + Weber</u>	
5. _____	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 7/31/78
 PROJECT FEATURE dam embankment NAME Mike Larson
 DISCIPLINE geotechnical NAME Ed Greco

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	<u>crest-paved asphalt road; grass + beach on up face; grass on down face</u>
Crest Elevation	<u>varies from 652.5 to 654.0</u>
Current Pool Elevation	<u>650.3</u>
Maximum Impoundment to Date	<u>unknown</u>
Surface Cracks	<u>alligator cracking on pavement of east abutment</u>
Pavement Condition	<u>poor</u>
Movement or Settlement of Crest	<u>none visible</u>
Lateral Movement	<u>none visible</u>
Vertical Alignment	<u>relatively flat</u>
Horizontal Alignment	<u>concave toward pond</u>
Condition at Abutment and at Concrete Structures	<u>right abutment-ties into natural hillside left abutment-bedrock outcrops</u>
Indications of Movement of Structural Items on Slopes	<u>none visible</u>
Trespassing on Slopes	<u>people in park</u>
Sloughing or Erosion of Slopes or Abutments	<u>no sloughing erosion - two areas on left side of dam, several pits + 1 gulley at 20' right of crest</u>
Rock Slope Protection - Riprap Failures	<u>no riprap, a few cut stones on both sides of spillway, shoreline receding due to wave erosion</u>
Unusual Movement or Cracking at or near Toes	<u>None visible</u>
Unusual Embankment or Downstream Seepage	<u>None visible</u>
Piping or Boils	<u>None visible</u>
Foundation Drainage Features	<u>None visible</u>
Toe Drains	<u>None visible</u>
Instrumentation System	<u>None</u>

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 7/31/78
 PROJECT FEATURE Spillway NAME Lyle Branagan
 DISCIPLINE geotechnical NAME Mike Larson

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	None
General Condition	N/A (not applicable)
Loose Rock Overhanging Channel	N/A
Trees Overhanging Channel	N/A
Floor of Approach Channel	N/A
b. Weir and Training Walls	granite slab overflow weir - granite slabs around top of vertical discharge shaft
General Condition of Concrete	poor
Rust or Staining	none
Spalling	west piece of granite slab weir has shifted out of place
Any Visible Reinforcing	none
Any Seepage or Efflorescence	water entering discharge shaft from underneath spillway weir
Drain Holes	none
c. Discharge Channel	vertical drop shaft - ^{mortared} stone walls
General Condition	very poor - filled with soil + trash to within 2ft of crest
Loose Rock Overhanging Channel	loose slab on weir
Trees Overhanging Channel	none
Floor of Channel	not visible
Other Obstructions	none

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 7/31/78
 PROJECT FEATURE diversion conduit NAME Mike Larson
 DISCIPLINE geotechnical NAME Dick Weber

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, <u>DIVERSION CONDUIT</u> <u>APPROACH AND DISCHARGE CHANNELS</u>	
a. <u>Intake Box</u> Approach Channel	concrete box conduit with opening on upstream face
General Condition	poor - trash + debris inside box, hole in top of box, trash gate on opening eroded,
Loose Rock Overhanging Channel	concrete spalled on upstream face of box none
Trees Overhanging Channel	yes
Floor of Approach Channel	trash + debris
b. <u>Conduit</u> Weir and Training Walls	reinforced concrete pipe - 2.5' diameter
General Condition of Concrete	blocked with leaves, trash, and soil
Rust or Staining	none visible
Spalling	none visible
Any Visible Reinforcing	none visible
Any Seepage or Efflorescence	none visible
Drain Holes	not applicable
c. Discharge Channel	not near site
General Condition	not inspected
Loose Rock Overhanging Channel	not inspected
Trees Overhanging Channel	not inspected
Floor of Channel	not inspected
Other Obstructions	not inspected

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 1/31/78
 PROJECT FEATURE outlet conduit NAME Lyle Branagan
 DISCIPLINE geotechnical NAME Mike Larson

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE</u>	
a. Approach Channel	<i>submerged - not visible</i>
Slope Conditions	<i>not visible</i>
Bottom Conditions	<i>not visible</i>
Rock Slides or Falls	<i>not visible</i>
Log Boom	<i>none</i>
Debris	<i>appears to be filled with sand</i>
Condition of Concrete Lining	<i>none</i>
Drains or Weep Holes	<i>none</i>
b. Intake Structure	<i>opening at bottom of upstream wall of spillway shaft</i>
Condition of Concrete ^{Masonry}	<i>not visible</i>
Stop Logs and Slots	<i>not visible</i>

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 7/31/78
 PROJECT FEATURE outlet conduit NAME Lyle Branagan
 DISCIPLINE geotechnical NAME Mike Larson

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	1.5'dia + 2.5'dia reinforced concrete pipe pipe visible at manholes
Rust or Staining on Concrete	none visible
Spalling	none visible
Erosion or Cavitation	none visible
Cracking	none visible
Alignment of Monoliths	not visible
Alignment of Joints	not visible
Numbering of Monoliths	not visible

PERIODIC INSPECTION CHECK LIST

PROJECT Green Hill Pond DATE 7/31/78
 PROJECT FEATURE outlet conduit NAME Lyle Branagan
 DISCIPLINE geotechnical NAME Mike Larson

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u>	
General Condition of Concrete	<i>good</i>
Rust or Staining	<i>none - water clear</i>
Spalling	<i>slight on tip</i>
Erosion or Cavitation	<i>none visible</i>
Visible Reinforcing	<i>none</i>
Any Seepage or Efflorescence	<i>discharging @ 5-10 gpm</i>
Condition at Joints	<i>not visible</i>
Drain Holes	<i>not visible</i>
Channel	<i>overgrown swamp-grass + weeds</i>
Loose Rock or Trees Over- hanging Channel	<i>none significant</i>
Condition of Discharge Channel	<i>cluttered with grass + weeds</i>

APPENDIX B
PLANS OF DAM AND PREVIOUS
INSPECTION REPORTS

	<u>Page</u>
Figure B-1 Plan of Dam	B-1
Figure B-2 Sections	B-2
Figures B-3 and B-4 Drawings of Dam, dated May 10, 1881	in pocket
Figure B-5 Drawing of Overflow Diversion, undated	in pocket
Previous Inspections (Partial Listing)	B-6
Inspection by Mass. Department of Public Works, dated February 5, 1973	B-7

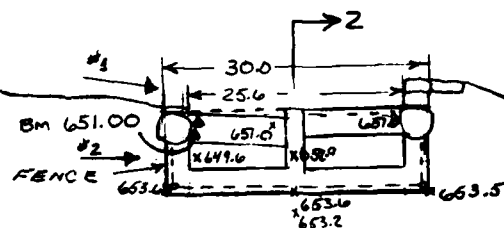
GREEN HILL POND

WS ELEV. 650

BEACH

X 651.7
X 652.8

X 653.6



Catch Basin

X 653.7
X 653.4

652.4

X 652.8
X 652.5

GREEN HILL PARKWAY

X 653.5

X 652.5

X 653.5
X 653.2

X 653.9

X 653.8

653.1

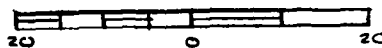
X 652.7

X 653.0
X 652.6

X 652.3
X 652.0

#3

Scale in Feet



X 646.0
→ 3

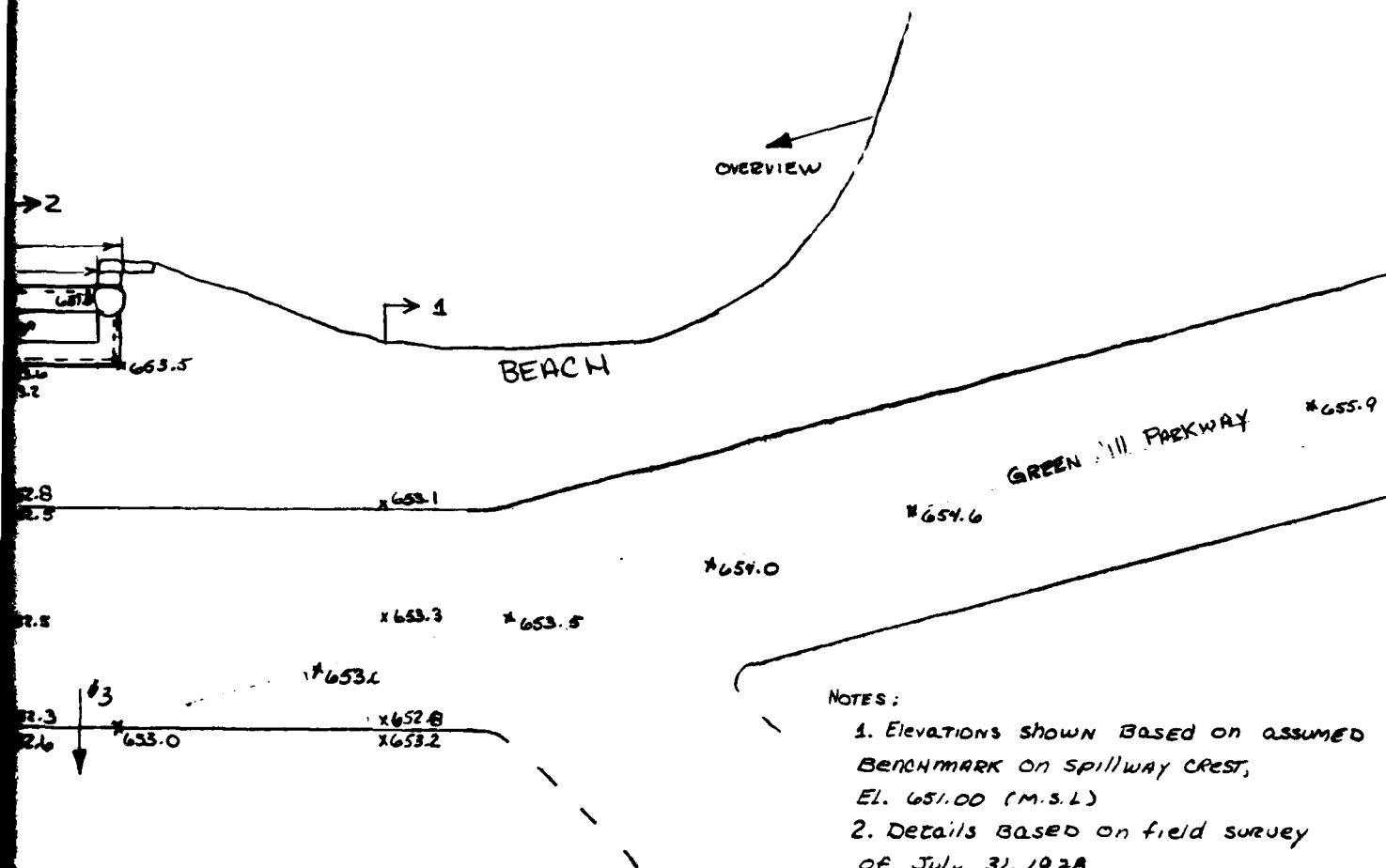
M.H. #1 INV. EL 636.7
U/S 1.5' CONC. PIPE
D/S 2.5' CONC. PIPE

X 640.9

X 640.9

2

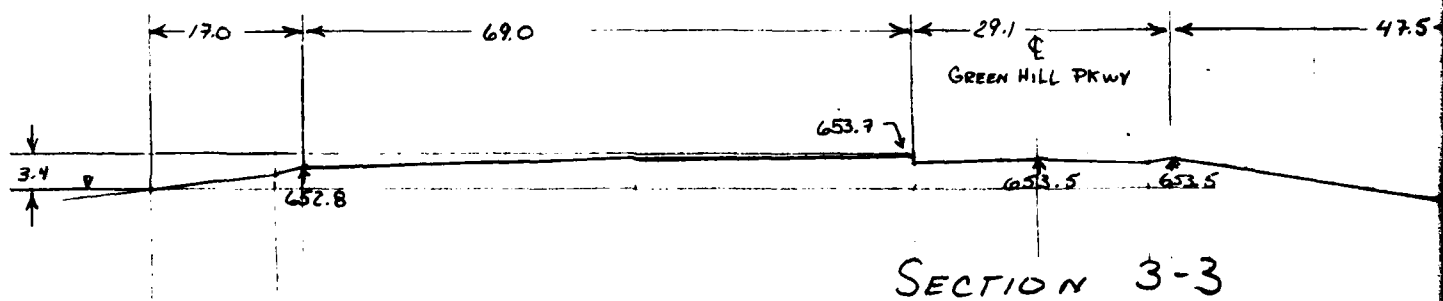
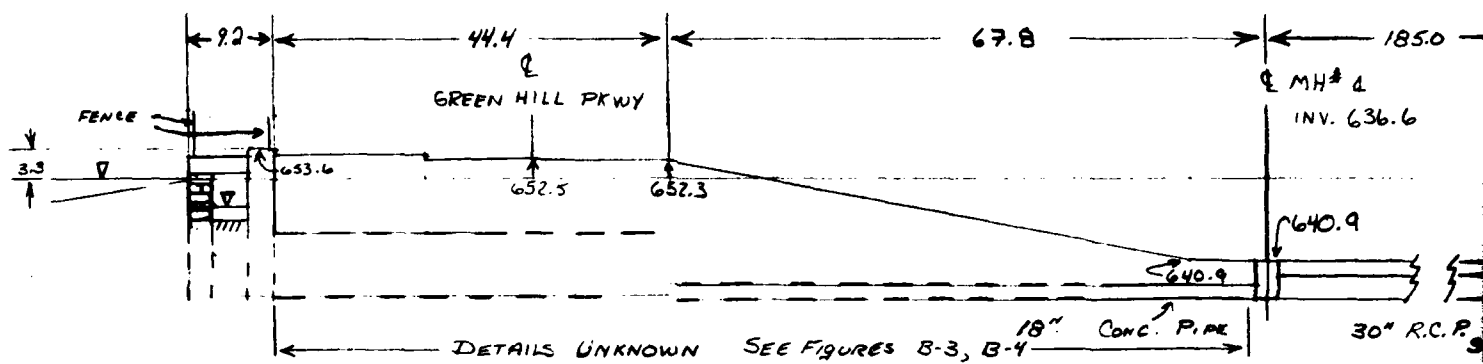
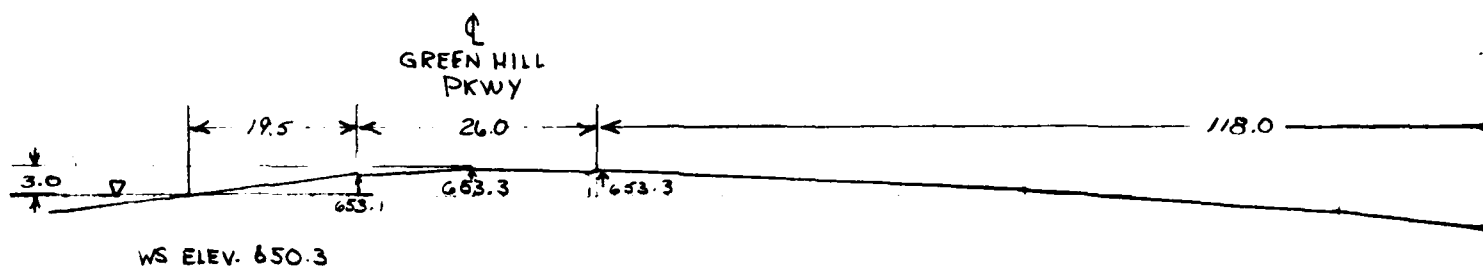
POND
ELEV. 650.3



NOTES:

1. Elevations shown BASED on assumed BENCHMARK ON SPILLWAY CREST, EL. 651.00 (M.S.L.)
2. Details BASED on field survey of July 31, 1978.
3. → #2 shows direction of view of photographs. PHOTO No. 4 TAKEN 450 FT. SOUTH OF MH. No. 1, LOOKING NORTH.
4. See figure B-2 for sections.

FIGURE B-1 PLAN OF DAM



METCALF & EDDY, INC

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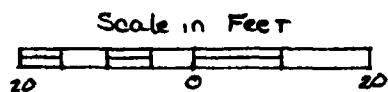
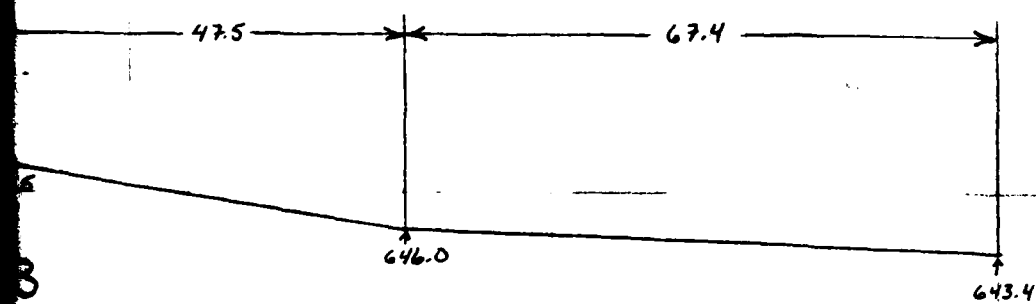
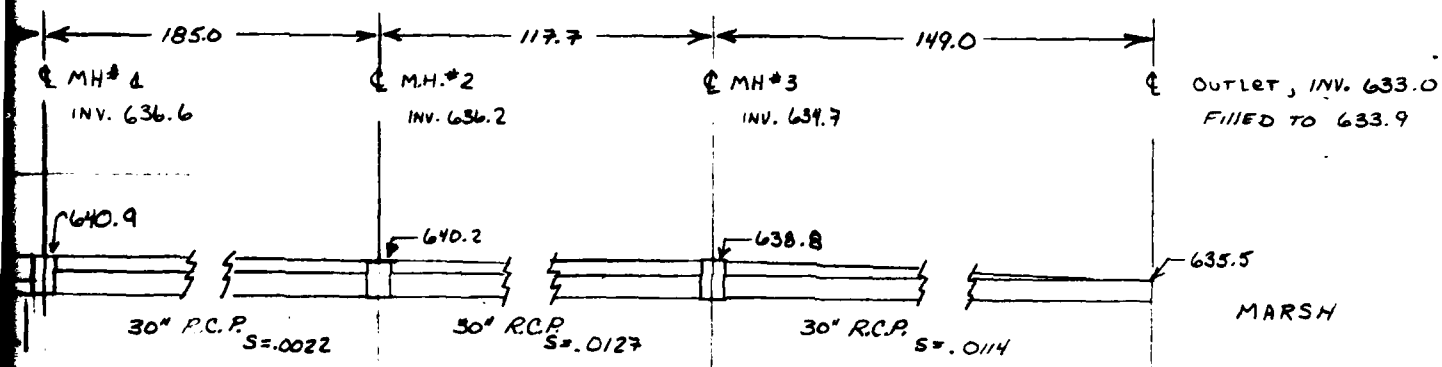
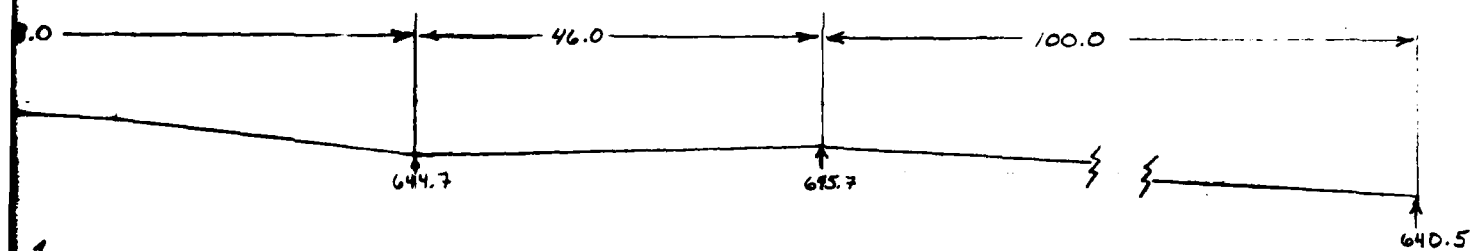


FIGURE B-2 SECTIONS

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FIGURE 2

WASTE

WASTE

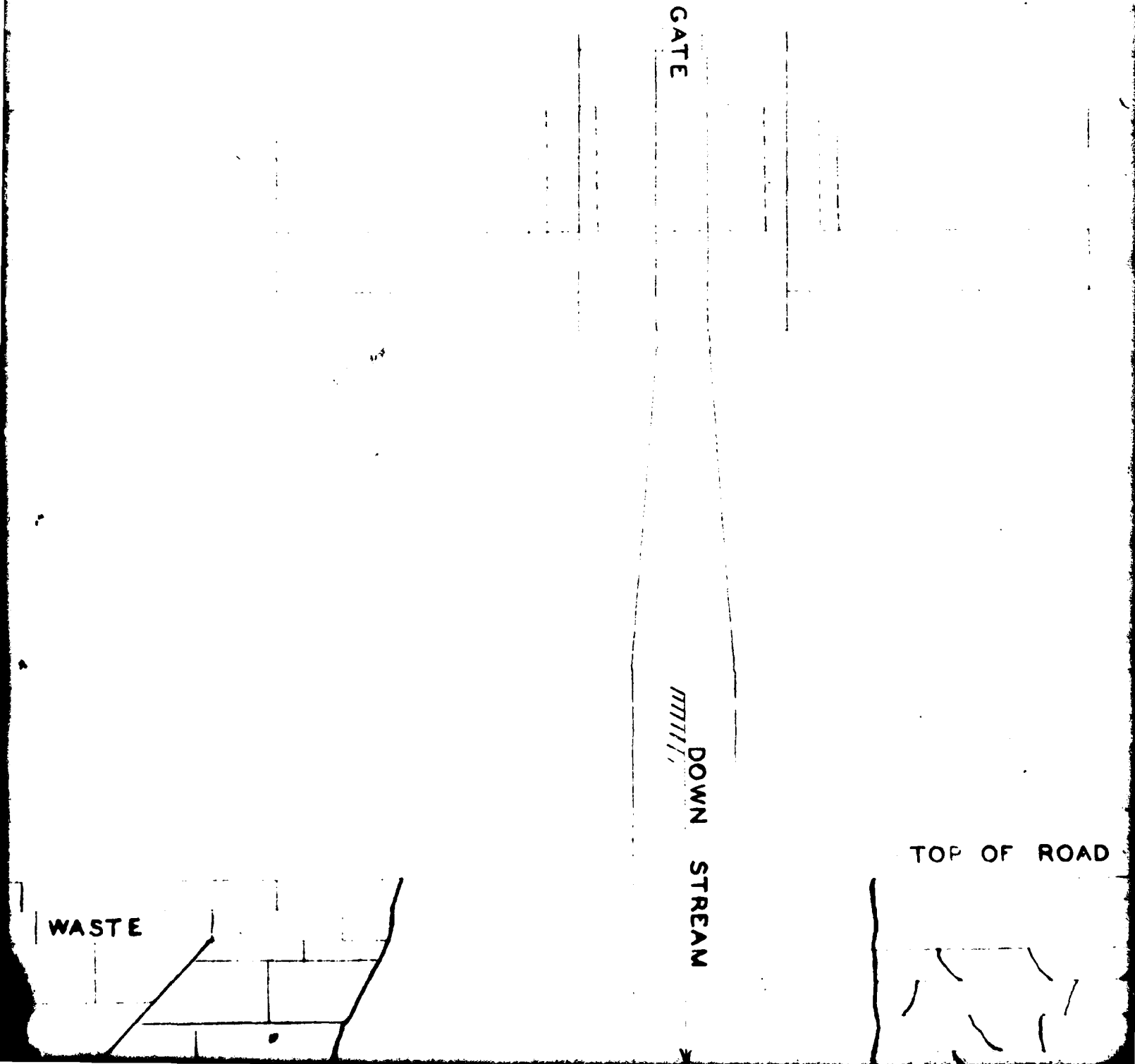
D

WASTE

WASTE

2

FIGURE 1



3

FIGURE 3

OF ROAD

D

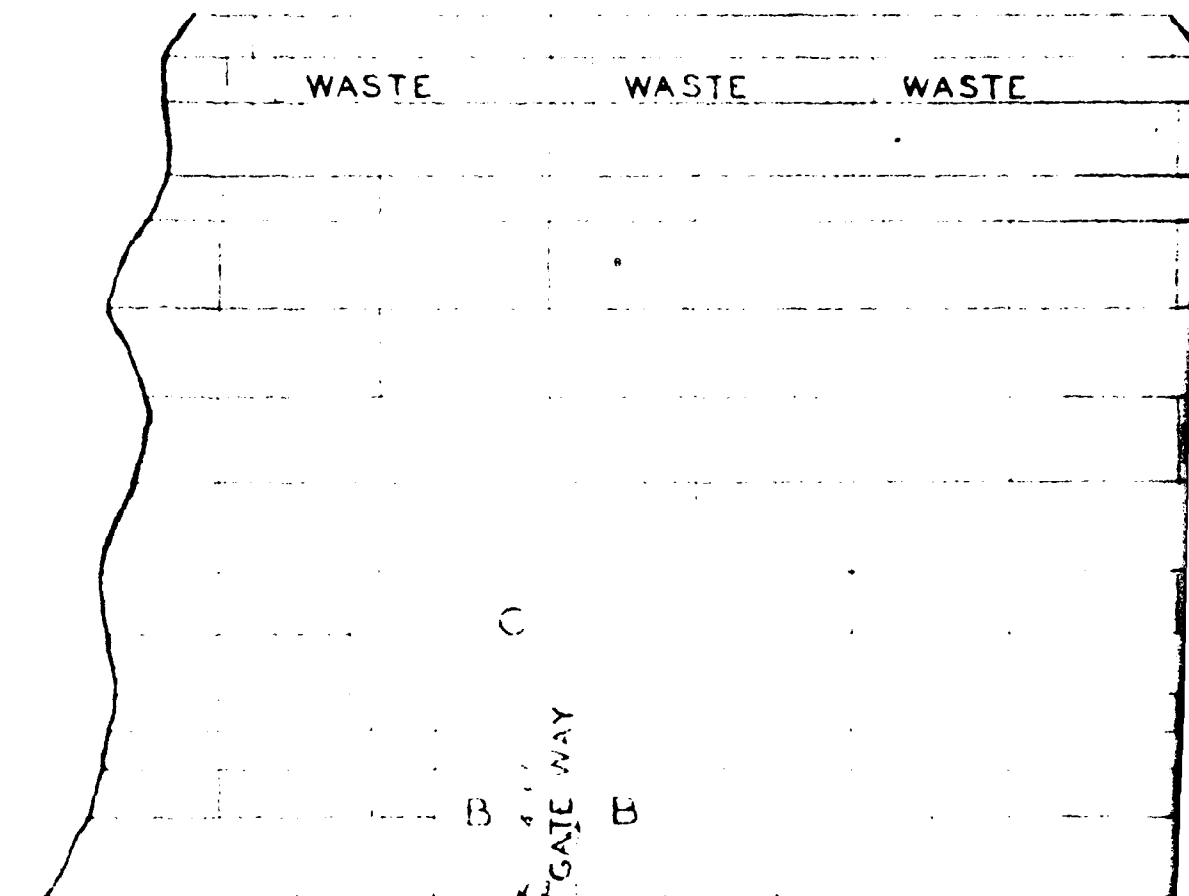
1/2 x 1/2

E

18'
OLL WAY

FIGURE 4

4



VIEW FROM NORTH
FACE OF CEMENT WALL

FIGURE 5

VIEW FROM SOUTH

TOP OF



5

WASTE

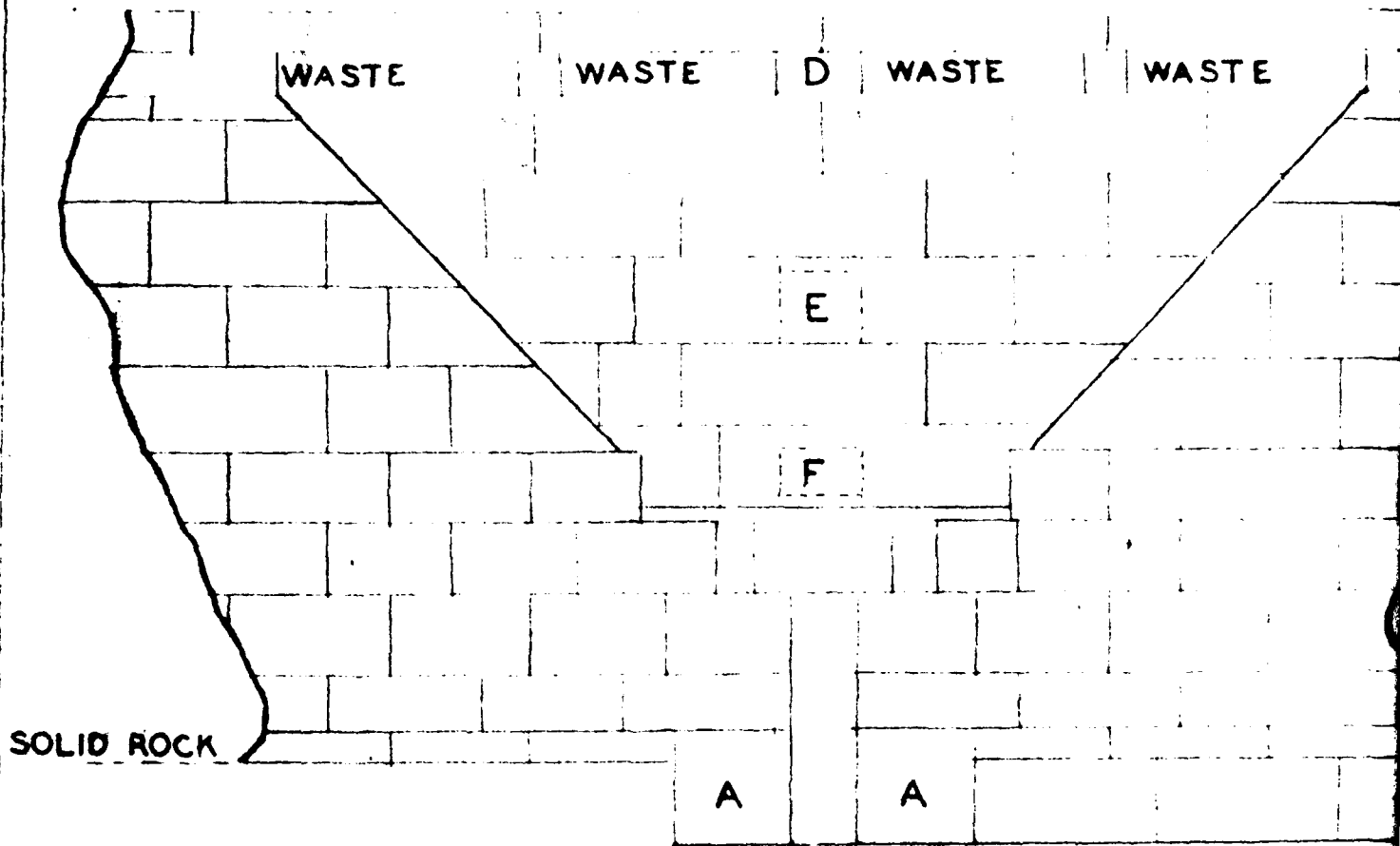
SOLID ROCK

WALL

ROAD

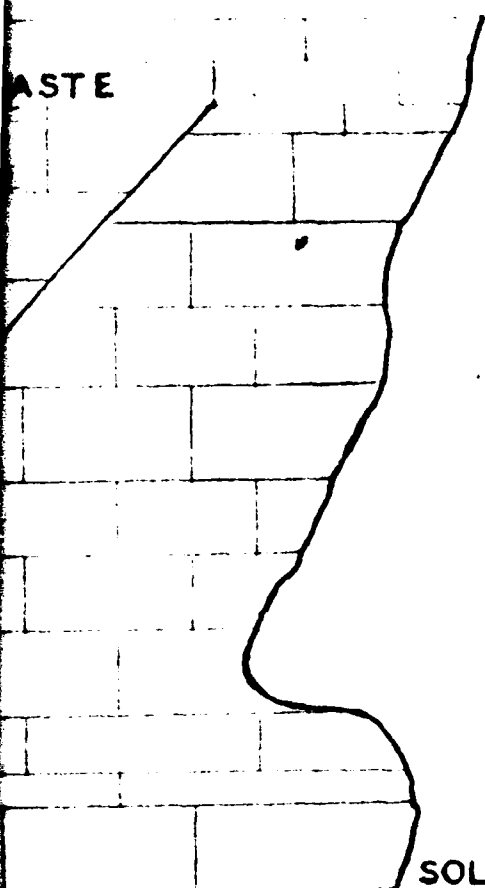
6

e



7

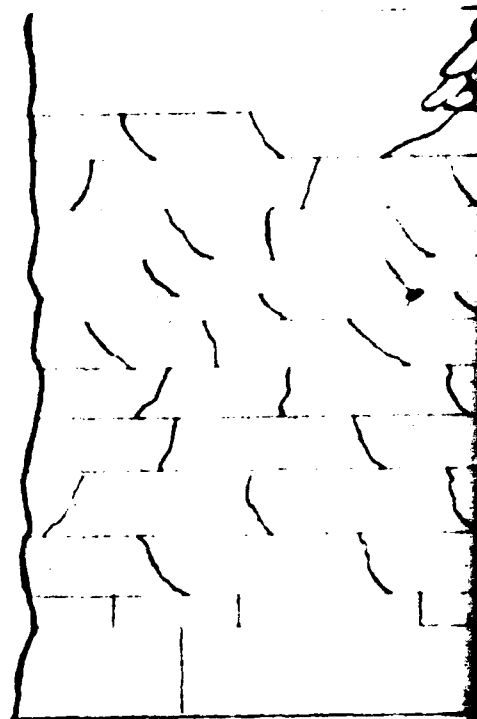
ASTE



SOLID ROCK

DOWN
STREAM

TOP OF ROAD

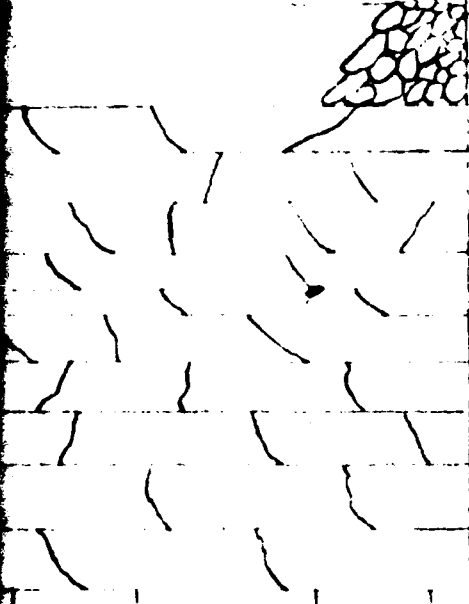


DAM AT GREEN HILL

SCALE 4FT = 1 INCH
MARTIN GREEN C. E.

8

TOP OF ROAD



D

E

F

C

A

B

1/2 x 1/2

18'
TO ROLL WAY

✓ SOLID ROCK

HILL

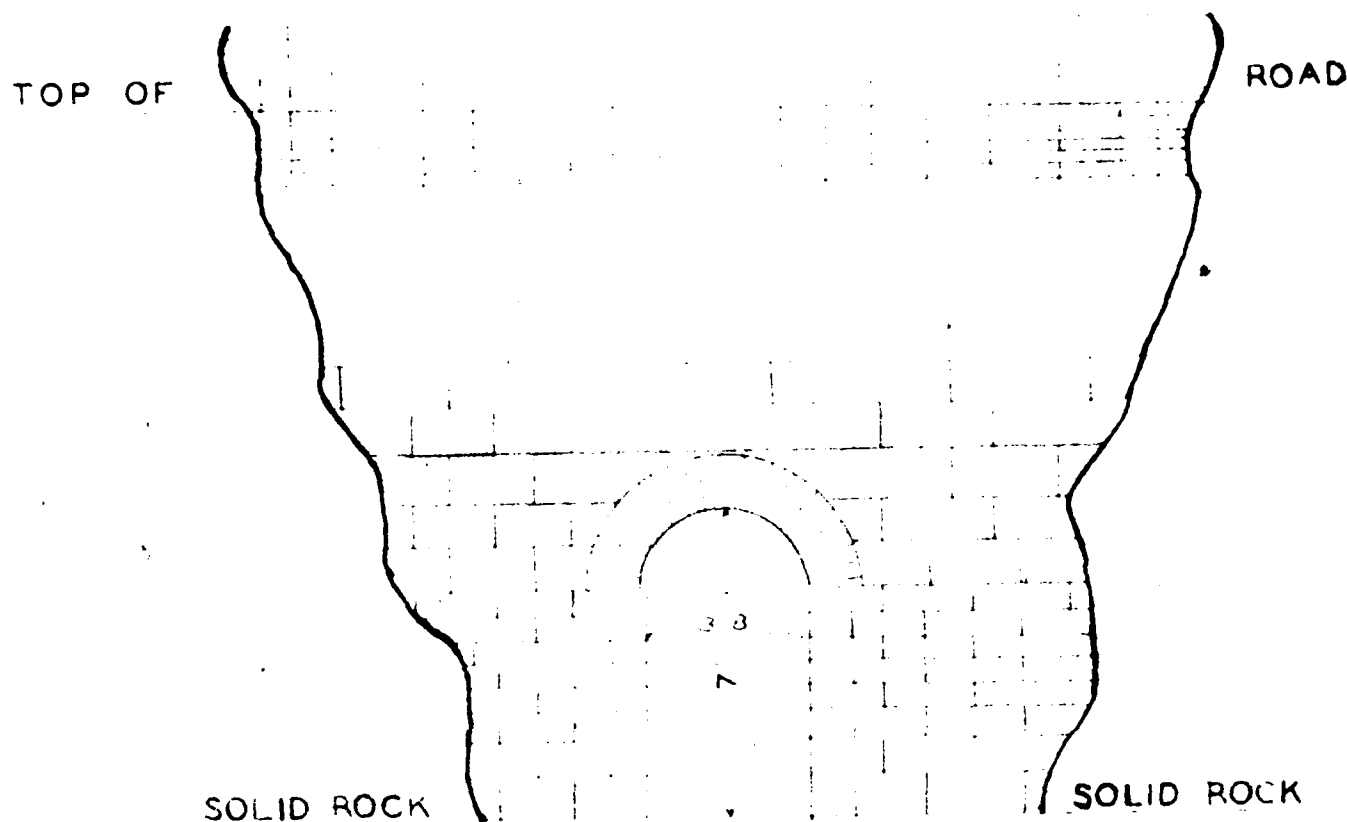
CH

C. E.

9

FIGURE 5

VIEW FROM SOUTH



WORCESTER COUNTY COMMISSION
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
GREEN HILL DAM
WORCESTER MASS

AS FILED AND APPROVED BY
COUNTY COMMISSIONER
MARCH MEETING DOCKET
SCALES AS NOTED

TRACED BY PRR

TRACING CHECKED BY

APPROVED MAY 10, 1881 BY

DAM N

D ROCK

SOLID ROCK

10.

WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
GREEN HILL DAM
WORCESTER MASS

AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
MARCH MEETING DOCKET #128
SCALES AS NOTED

TRACED BY PPP

DAM NO 61-23

TRACING CHECKED BY

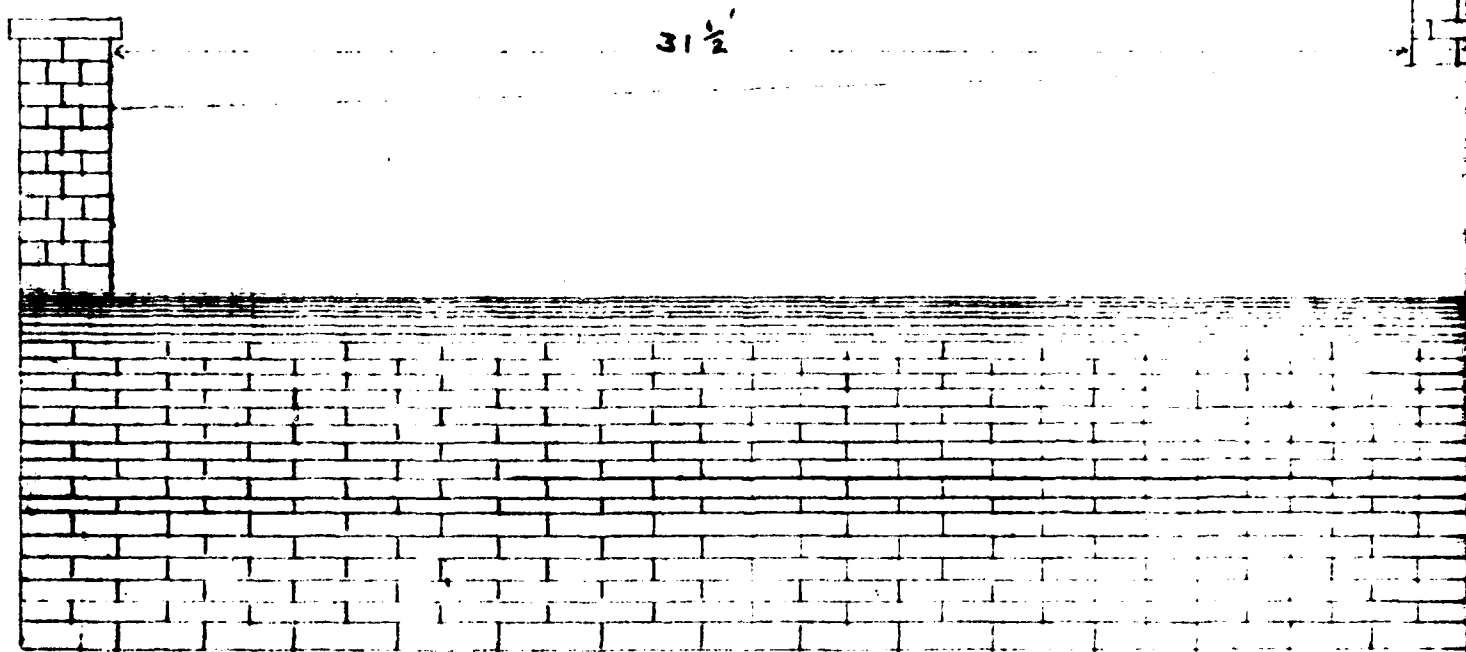
APPROVED MAY 10, 1881 BY

NO. - 61-23

FIGURE B-3

DAM NO-61-23

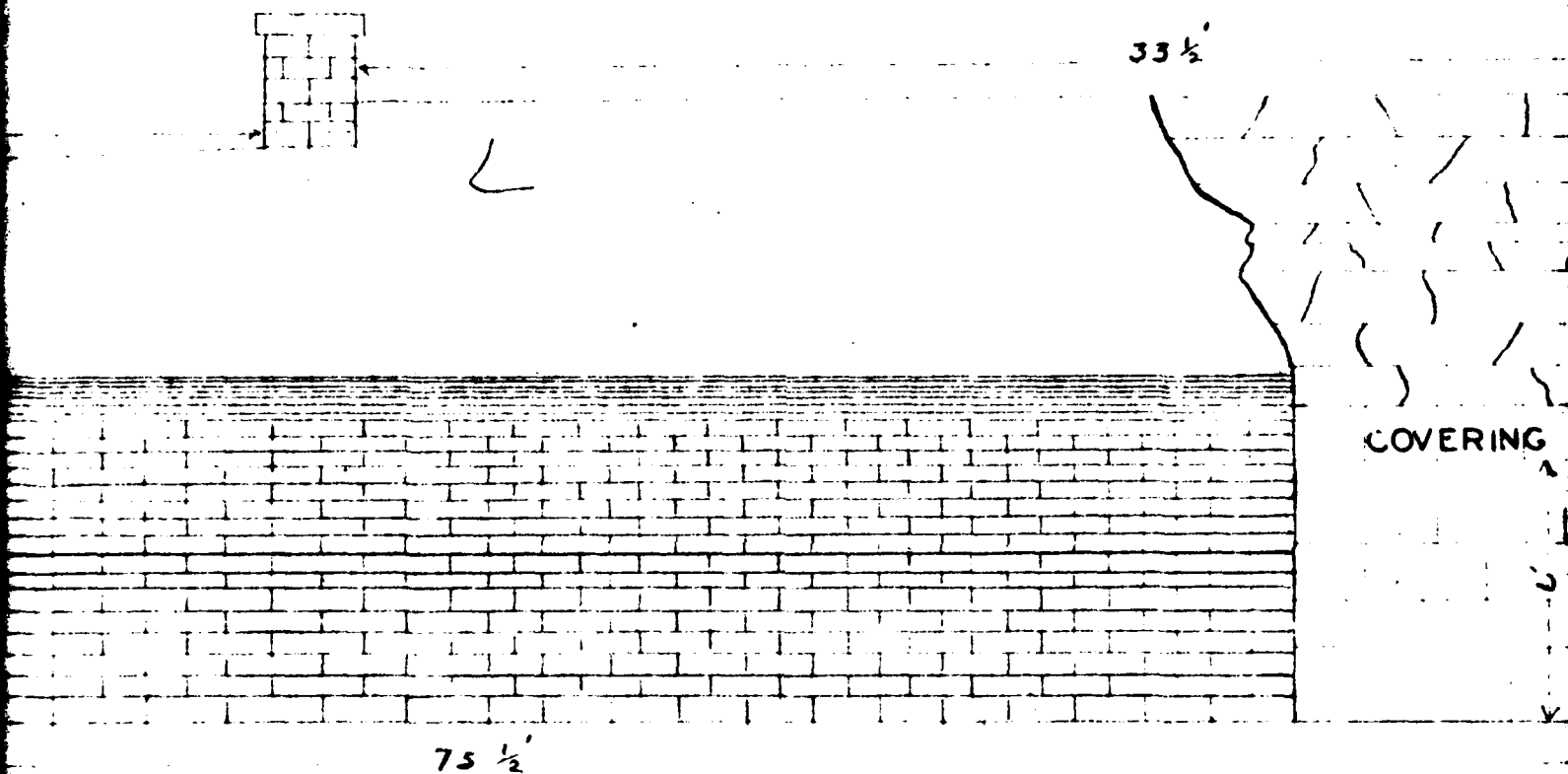
FIGURE



LONGITUDINAL SECTION
AND
CROSS SECTION OF

FIGURE 7

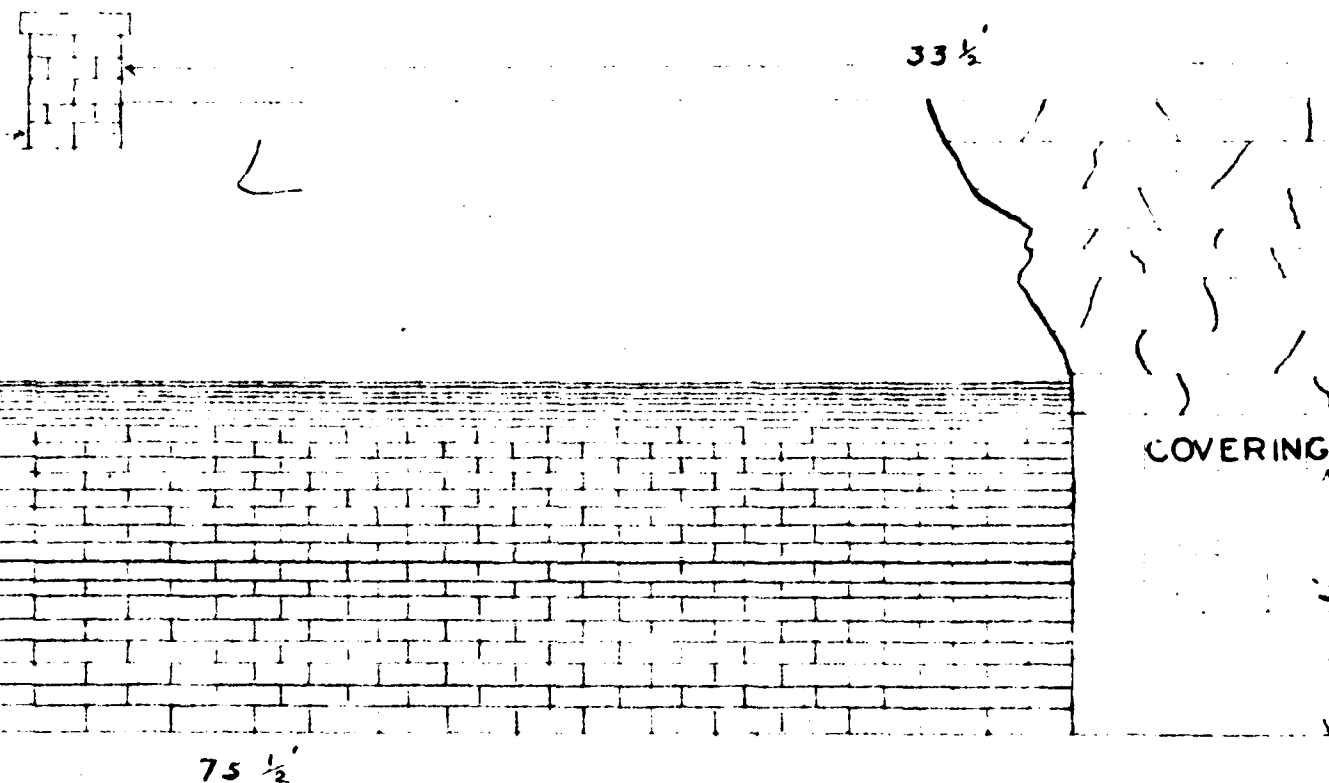
FIGURE 6



LONGITUDINAL SECTION OF CULVERT
AND
SECTION OF DAM AND ROADS

2

FIGURE 6



LONGITUDINAL SECTION OF CULVERT
AND
SECTION OF DAM AND ROADS

3

COVERING STONE

NORTH LINE OF OLD DAM

D

E

F

A

GATE WAY
46 x 13

GATE
WAY

NORTH FACE OF CEMENT WALL

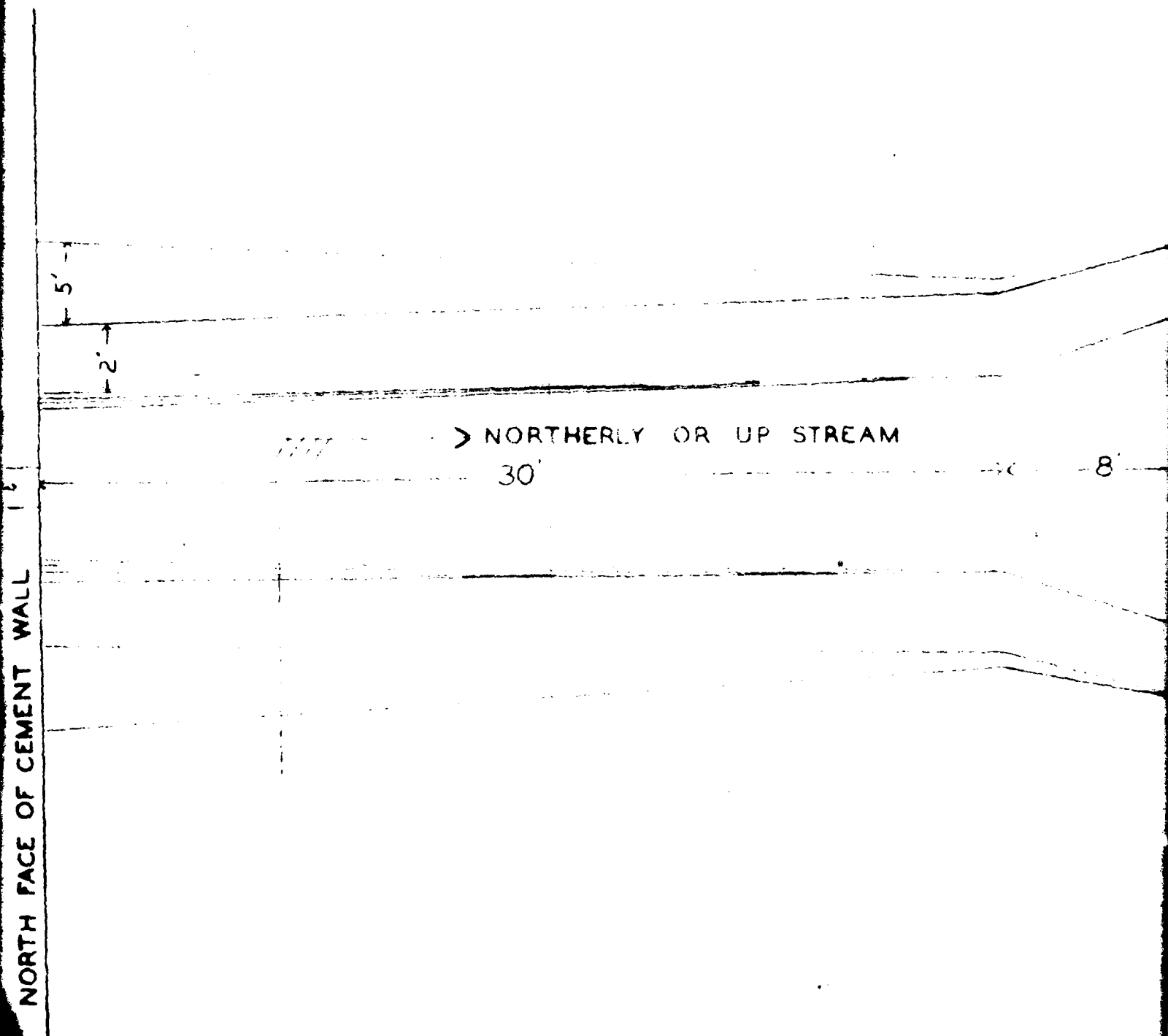
5'

2'

SHEET 2 OF 2 SHEETS

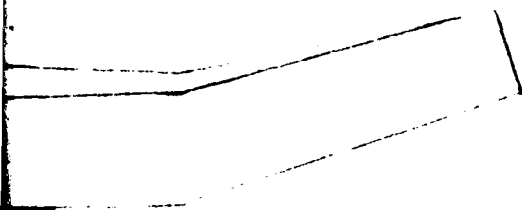
4

FIGURE 8



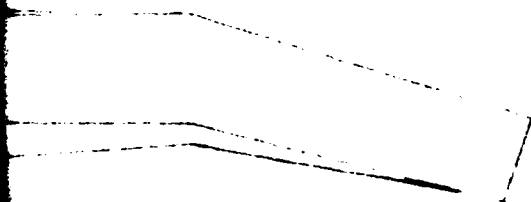
SHEETS

5

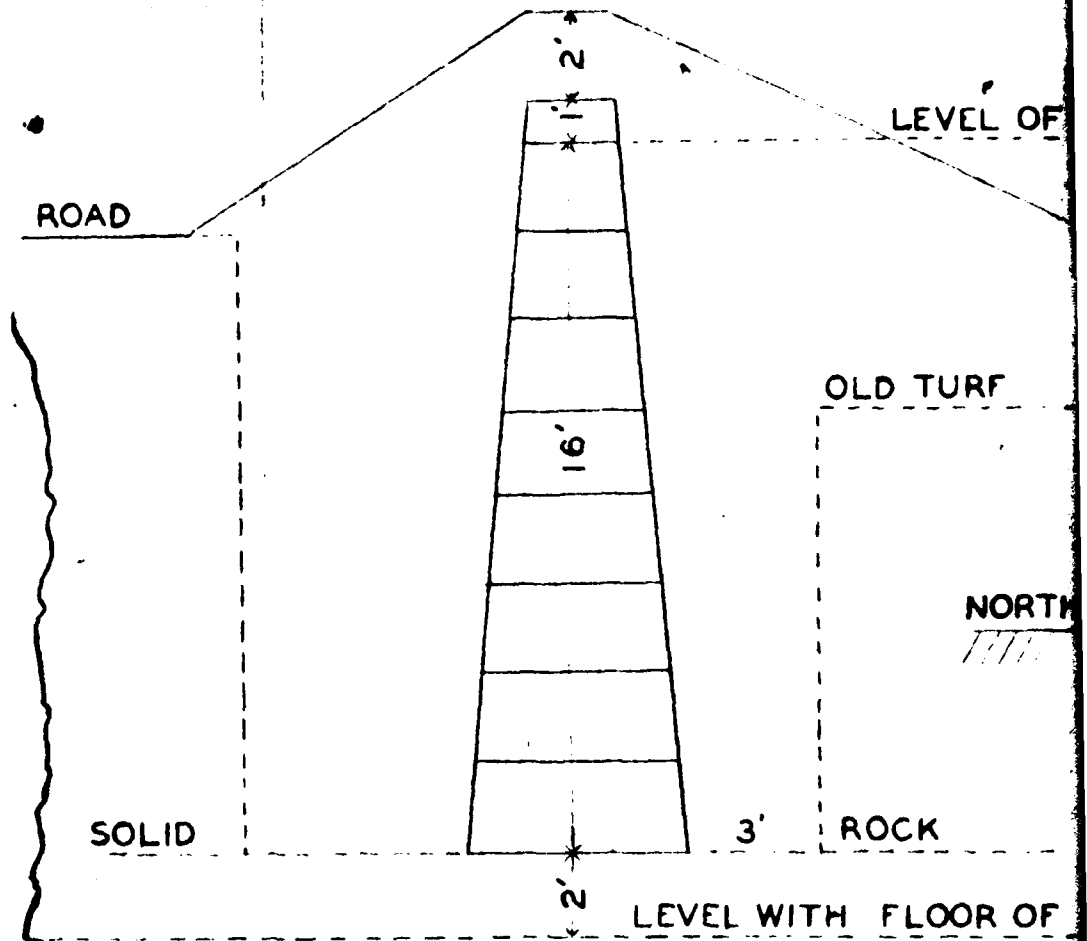


AM

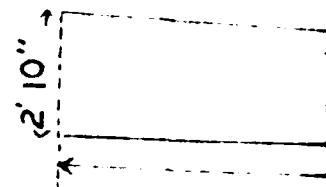
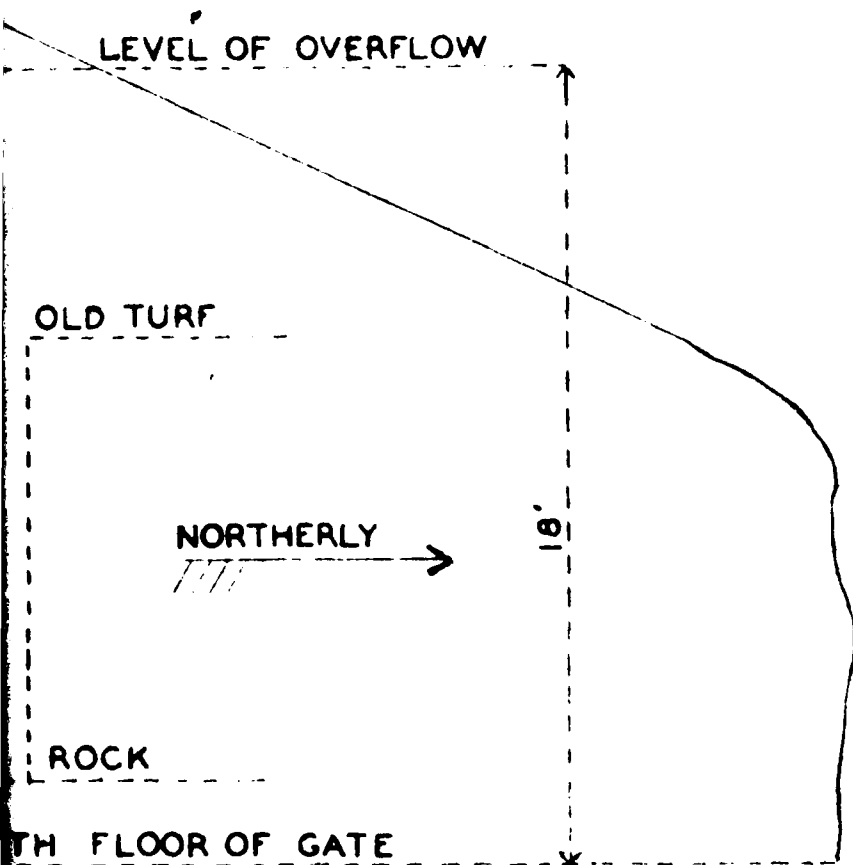
8



6



7



DAM AT GREEN HILL

SCALE 4 FT = 1 INCH

MARTIN GREEN C. E.

3

FIGURE 9



PROFILE OF ROCK FOUND ^N/₁₁

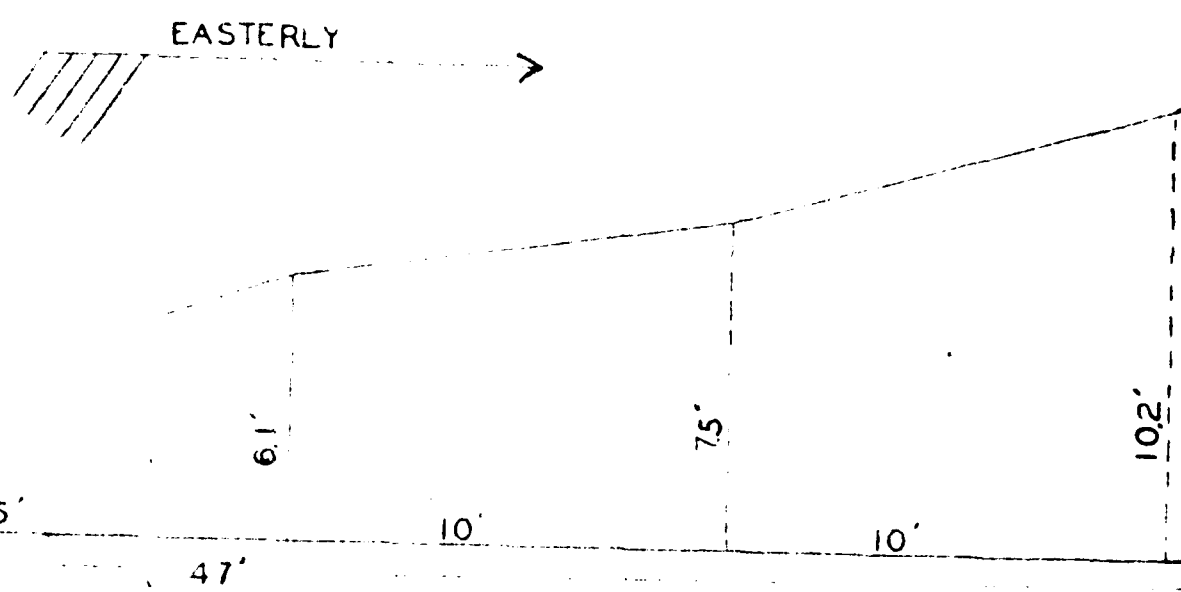
GREEN HILL

= 1 INCH

GREEN C. E.

9

9



CK FOUND ^N/₁₁ OF CEMENT WALL

DAM NO. - 61-23

10

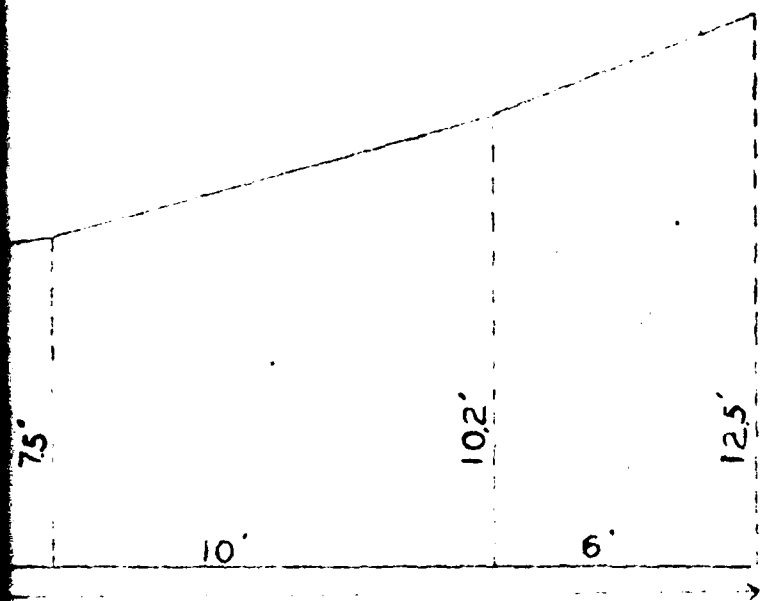
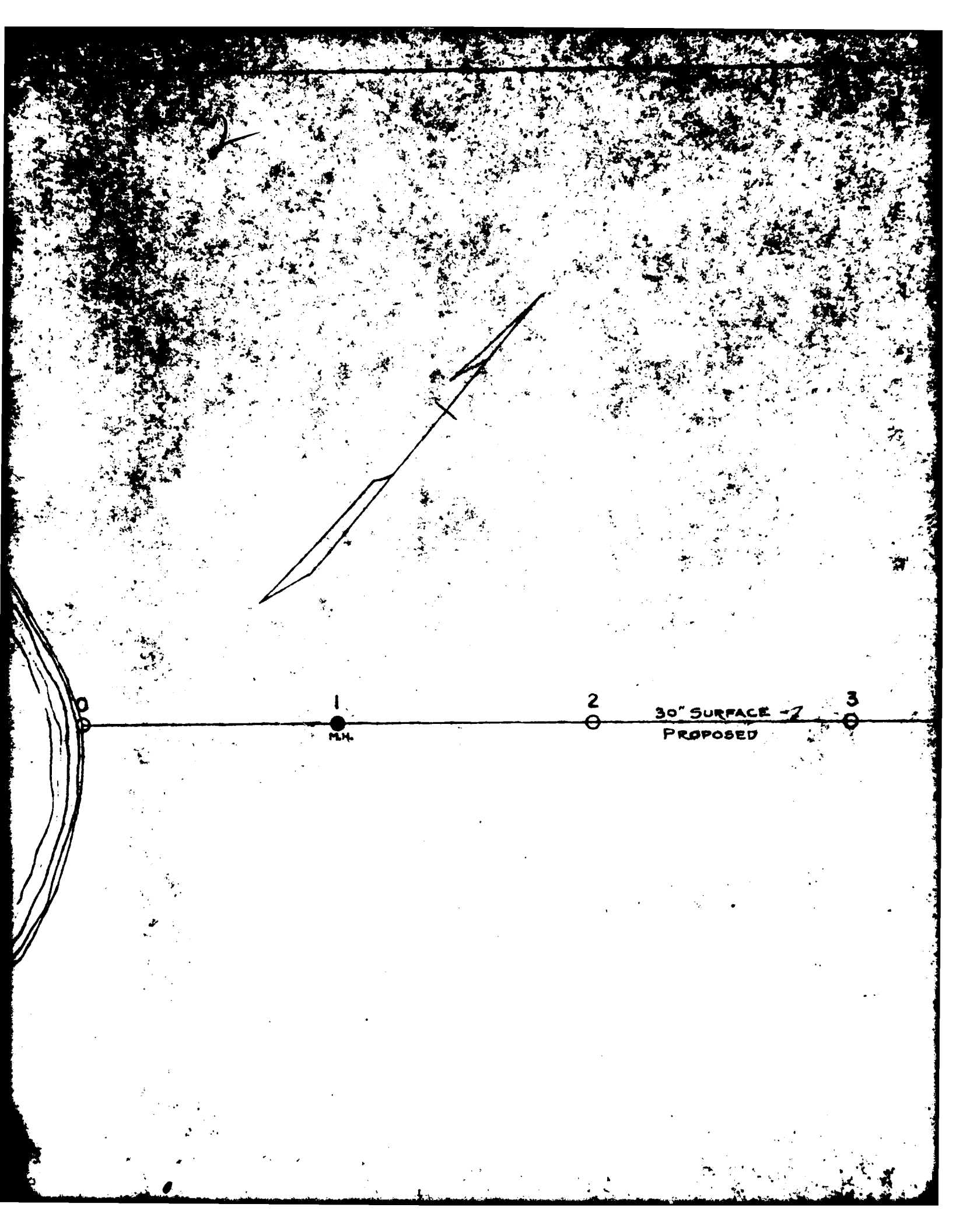


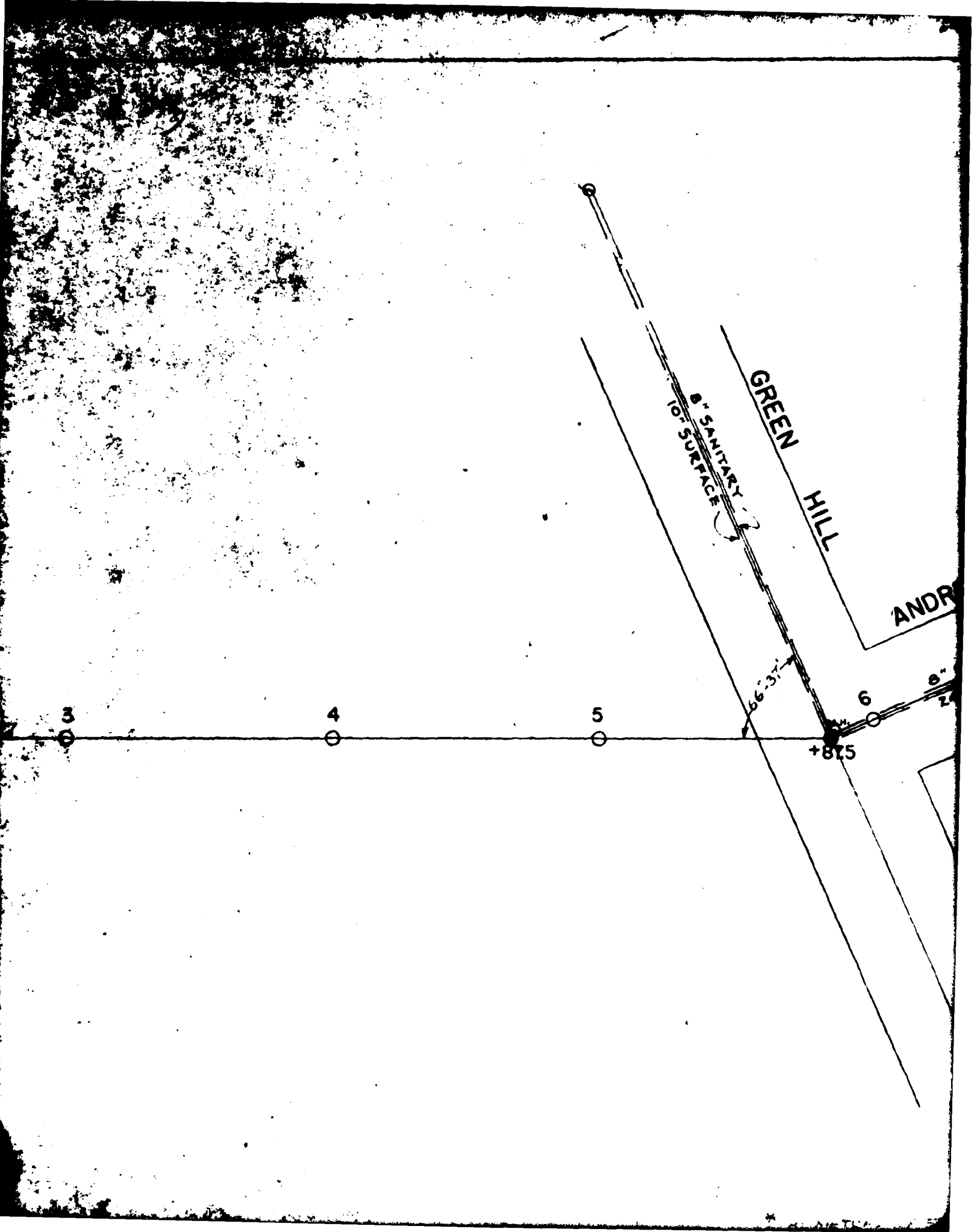
FIGURE B-4

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GREEN HILL POND





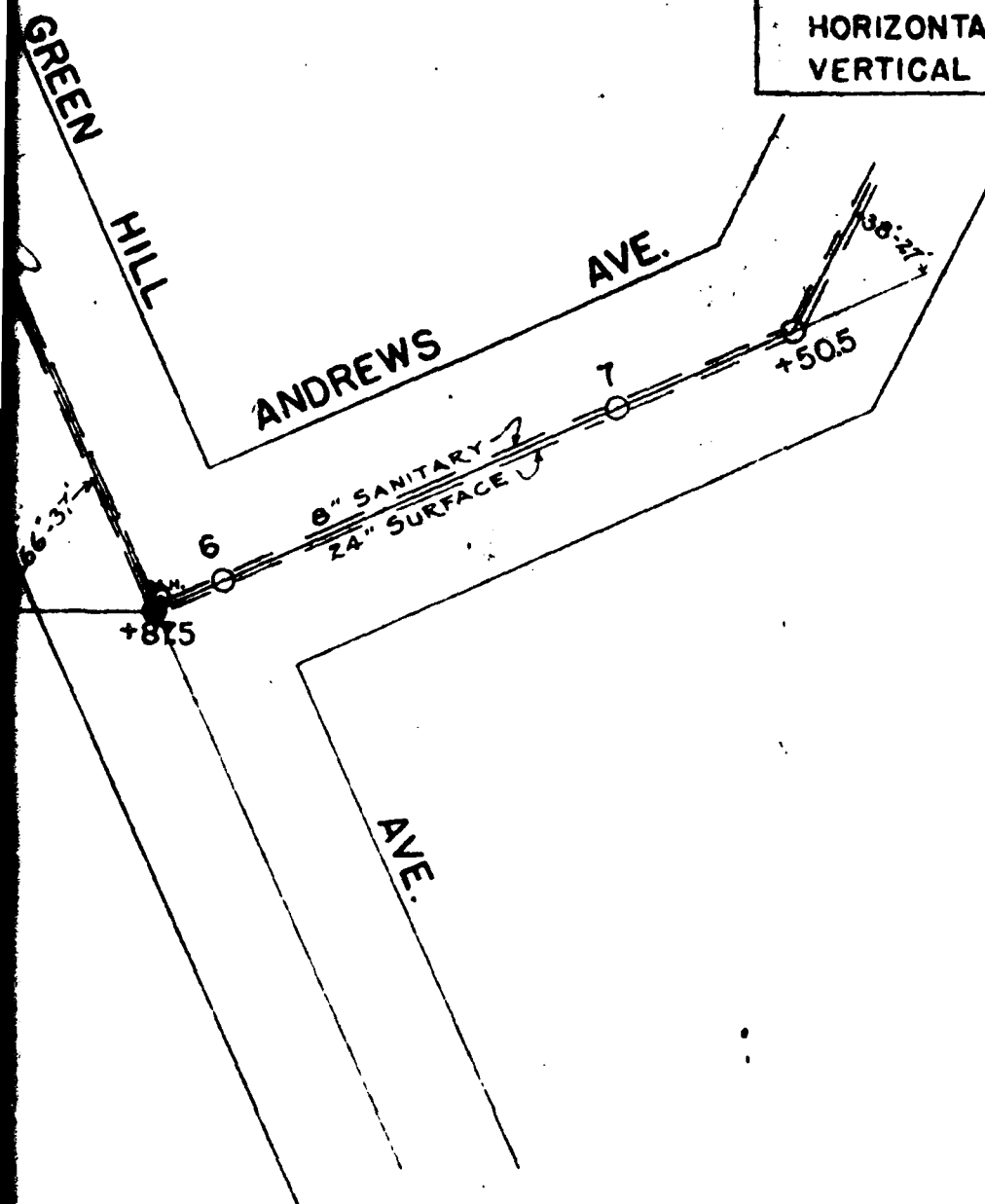


4

PLAN & PROFILE
 GREEN HILL POND
 DIVERSION OF OVERFLOW
 CITY OF WORCESTER MASS

STA. 0+00 TO STA. 29+00

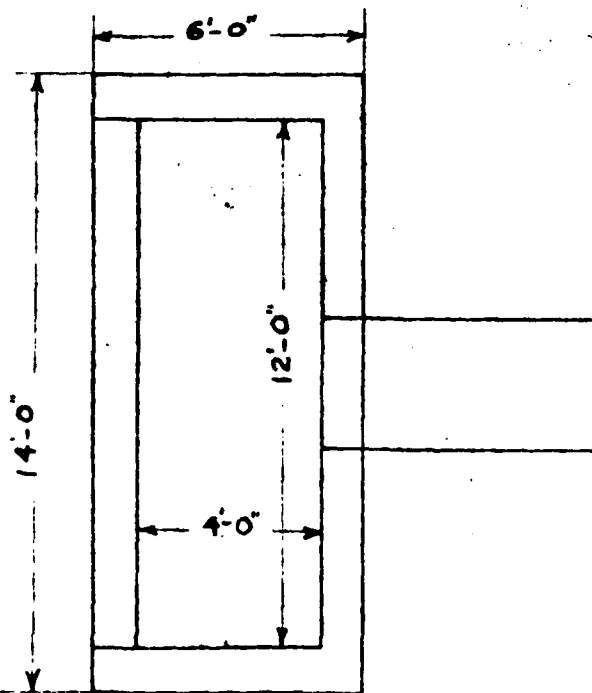
HORIZONTAL SCALE 40 FEET TO AN INCH
 VERTICAL SCALE 8 FEET TO AN INCH



PLAN OF INTAKE
 SCALE 1/4" TO A FOOT

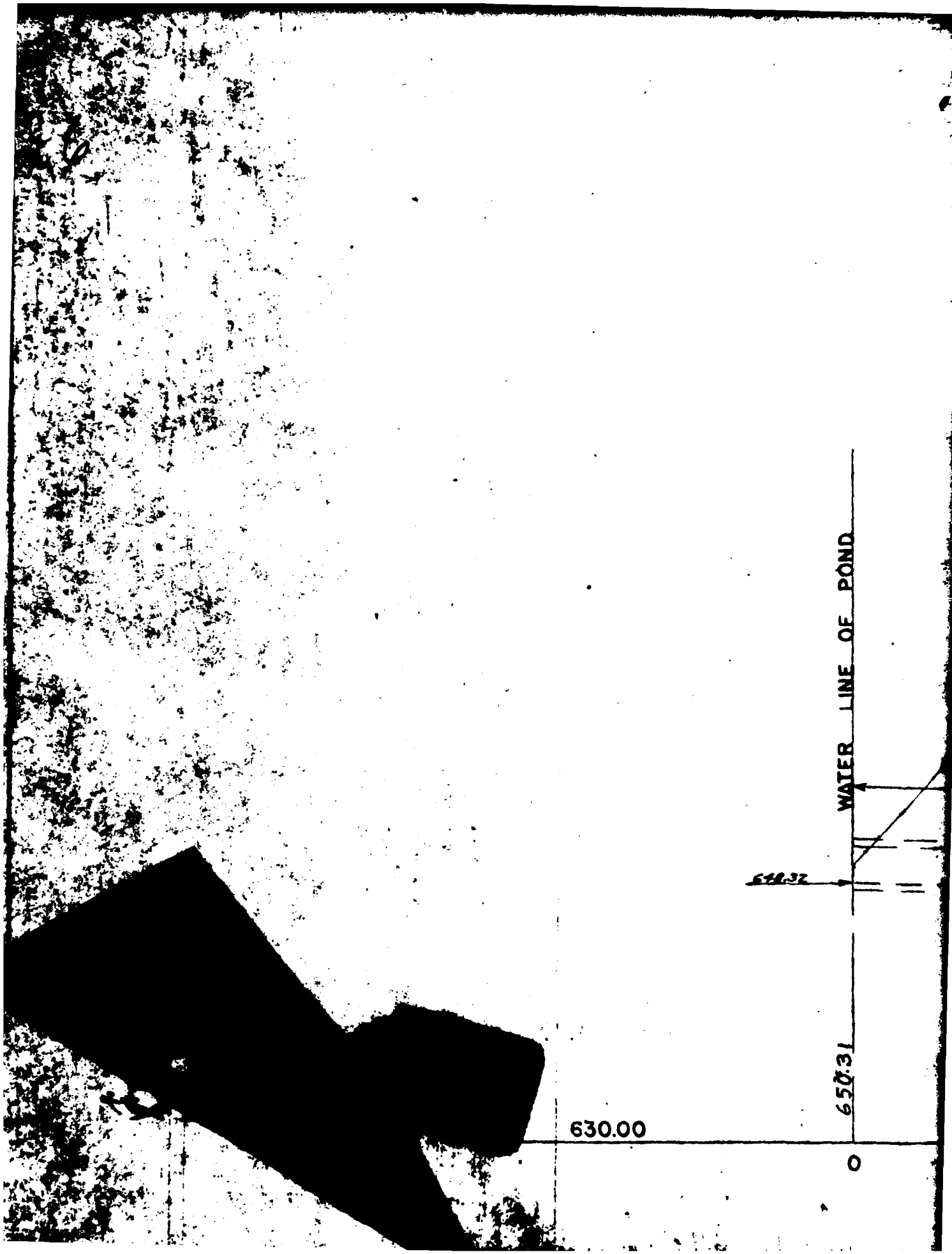
5

PLAN & PROFILE
 GREEN HILL POND
 SECTION OF OVERFLOW
 WORCESTER MASS.
 TO STA. 29+07
 SCALE 40 FEET TO AN INCH
 SCALE 8 FEET TO AN INCH

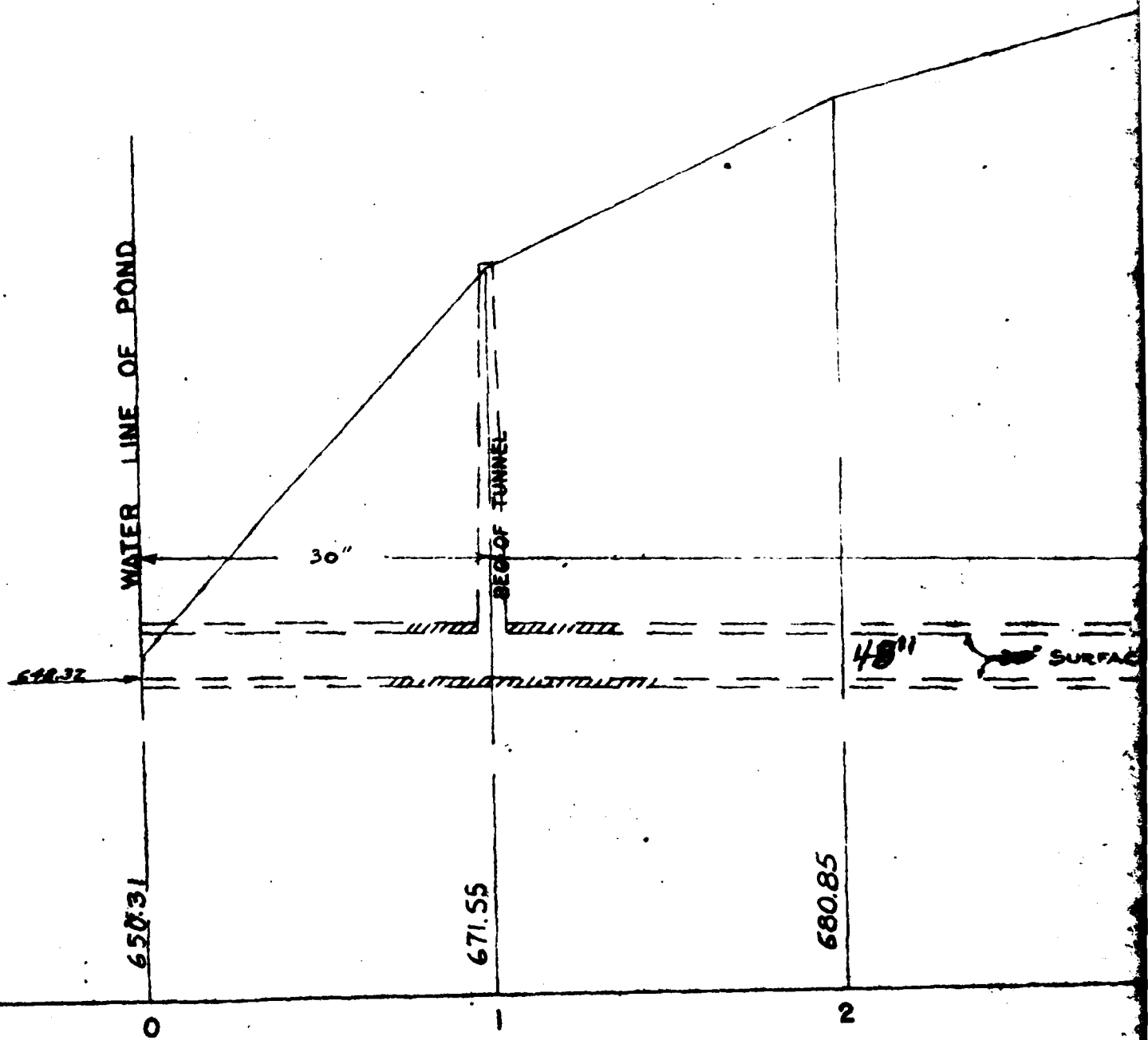


PLAN OF INTAKE
 SCALE 1/4" TO A FOOT

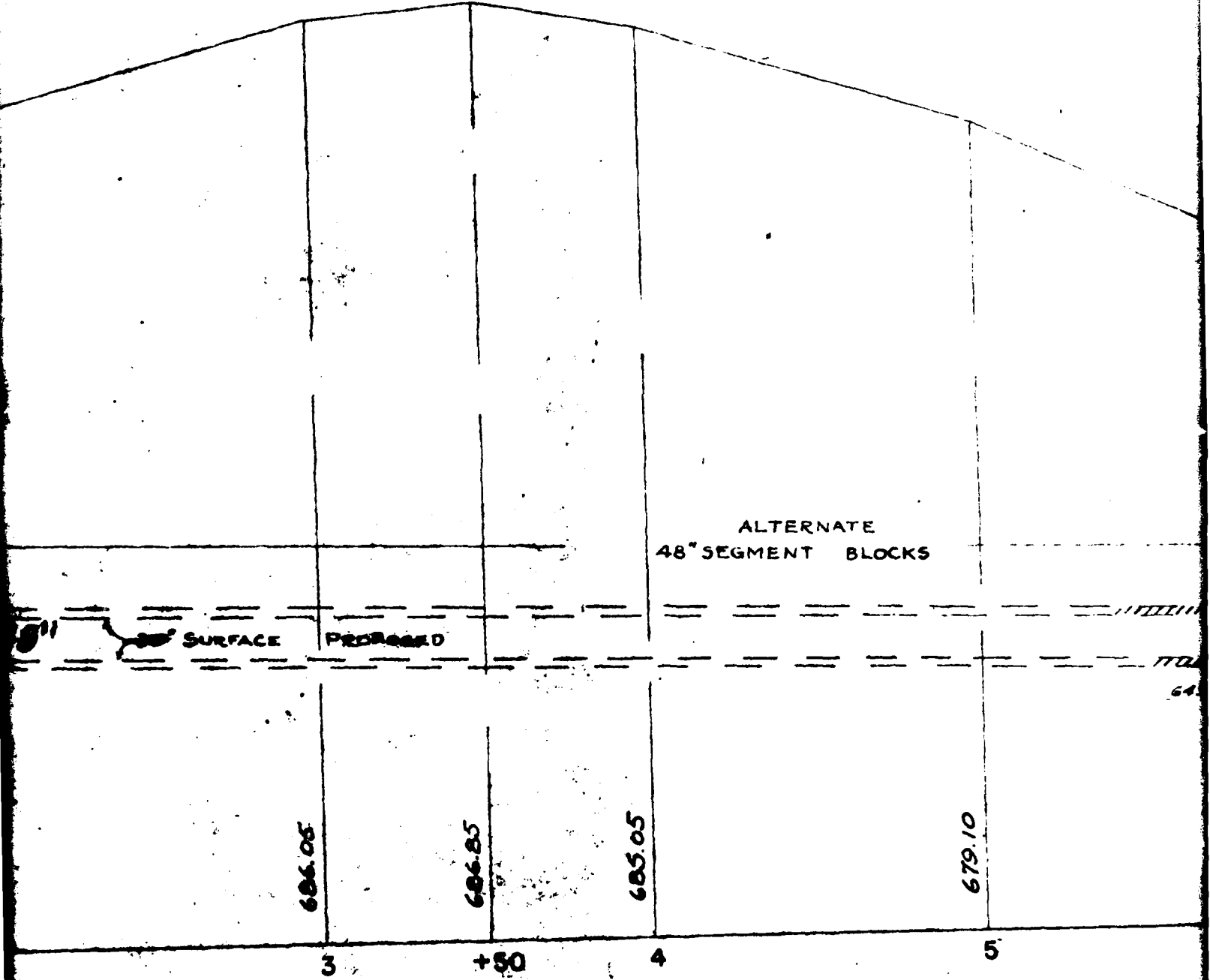
PRESENT GROUND



7



8



ALTERNATE
48" SEGMENT BLOCKS

SURFACE PROPOSED

686.05

686.85

685.05

679.10

3

+30

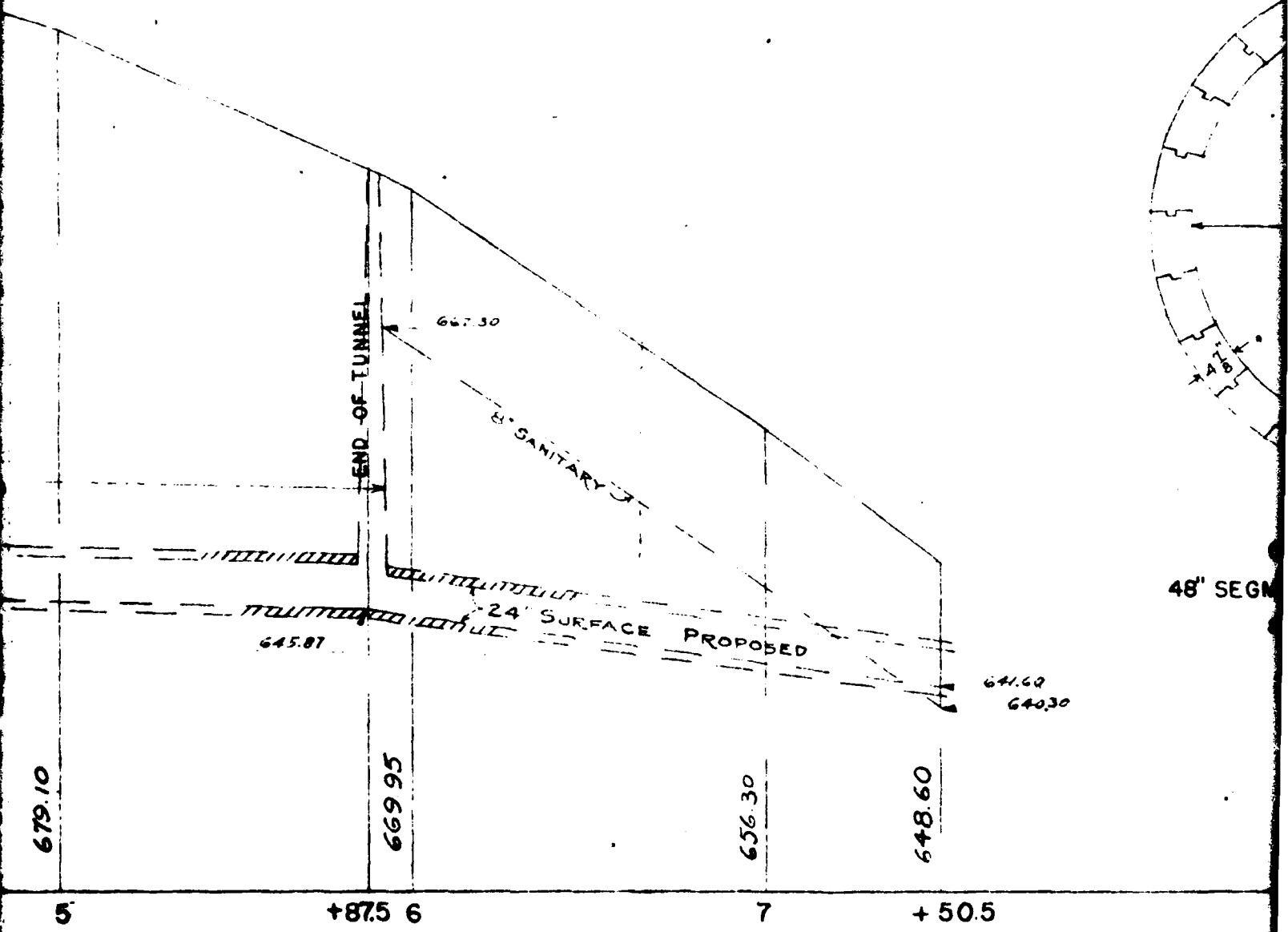
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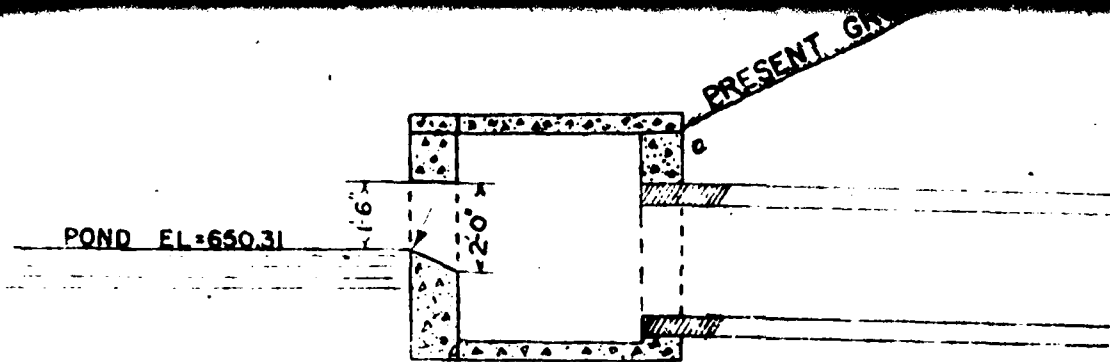
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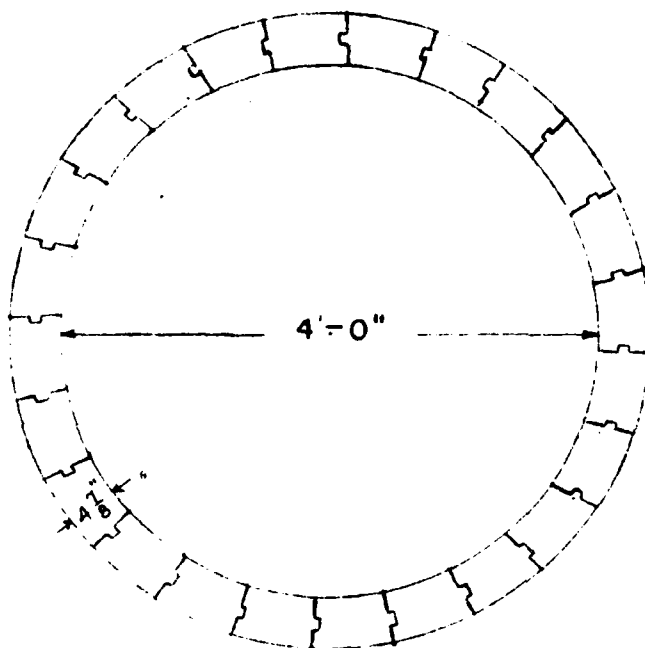
POND EL=650.31

SC





SECTION
SCALE $\frac{1}{4}$ " TO A FOOT



CROSS SECTION
48" SEGMENT BLOCK SEWER
SCALE $\frac{3}{4}$ " TO A FOOT

641.69
640.30

TOWN OR CITY <i>Worcester</i> DECREE NO.		PLAN NO.	DAM NO. <i>61-23</i>
LOCATION <i>Green Hill Park</i>		C. C. DOCKET NO. <i>128</i>	
DESCRIPTION OF DAM		DESCRIPTION OF RESERVOIR & WATERSHED	
Type <i>Granite & Earth</i>	<i>on Solid Rock</i>	Name of Main Stream	
Length		" " any other Streams	
Height	<i>20.0 ft</i>	Length of Watershed	
Thickness top		Width "	
" bottom		Is Watershed Cultivated	
Downstream Slope	<i>1 1/2:1 to Road</i>	Percent in Forests	
Upstream "	<i>2:1</i>	Steepness of Slope	
Length of Spillway	<i>22.00 - 15.00 each side of gate.</i>	Kind of Soil	
Size of Gates	<i>15" wide x 4' 6" high</i>	No. of Acres in Watershed	
Location of Gates		" " " Reservoir	<i>27.</i>
Flashboards used		Length of Reservoir	
Width Flashboards or Gates		Width "	
Dam designed by	<i>Martin Green C. E.</i>	Max Flow Cu. Ft. per Sec.	
" constructed by		Head or Flashboards-Low Water	
Year constructed	<i>1881</i>	" " " High	
GENERAL REMARKS		GENERAL REMARKS	
<i>City of Worcester Park Dept.</i> <i>Vol. 26- P. 444 - Martin Green</i> <i>May 19, 1881</i> <i>Inspected: Nov. 17, 1938 - L. H. Spafford</i> <i>Measured: March 1, 1939 - E. J. Grover - D. F. Day.</i>			

U.S. Library Bureau 10-57708

PREVIOUS INSPECTIONS (PARTIAL LISTING)
 COPY OF INSPECTION CARD ON FILE AT THE MASSACHUSETTS
 DEPARTMENT OF PUBLIC WORKS, DISTRICT OFFICE, WORCESTER.

DESCRIPTION OF DAM

DISTRICT 3

Submitted by MULCAHY & DONAHUE Dam No. 3-14-348-23

Date 2-5-73 City/Town WORCESTER

Name of Dam GREEN HILL POND

1. Location: Topo Sheet No. 20 D

Provide 8 1/2" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: _____ Year/s of subsequent repairs _____

3. Purpose of Dam: Water Supply _____ Recreational ☒

Irrigation _____ Other _____

4. Drainage Area: 122 sq. mi. _____ acres

5. Normal Ponding Area: 27 acres; Ave. depth _____

Impoundments: _____ gals.; _____ acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

NONE i.e. summer homes, etc. _____

7. Dimensions of Dam: Length 80' Max. Height 12'

Slopes: Upstream Face VERTICAL

Downstream Face 2-1

Width across top 50'

8. Classification of Dam by Material:

Earth ☒ Conc. Masonry _____ Stone Masonry ☒

Timber _____ Rockfill _____ Other _____

9. A. Description of present land usage downstream of dam:

50 % rural; 50 % urban.

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes ☒ no _____

DAM NO. 3-14-348-23

10. Risk to life and property in event of complete failure.

No. of people NONE .
No. of homes NONE .
No. of Businesses NONE .
No. of industries NONE . Type _____
No. of utilities NONE . Type _____
Railroads NO .
Other dams NONE .
Other _____ .

11. Attach Sketch of dam to this form showing section and plan on 8 1/2" x 11" sheet.

12. How to locate: FROM BELMONT ST, VP SKYLINE DRIVE
STAY ON THIS ROAD DAM VISIBLE ON RIGHT AT
RECREATIONAL PARKING AREA.

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/Town WORCESTER Dam No. 3-14-348-23

Name of Dam GREEN HILL POND Inspected by MULCAHY DONAHUE

Date of Inspection 2-5-73

2. Owner/s: per: Assessors _____ Prev. Inspection ✓

Reg. of Deeds _____ Pers. Contact _____

1. CITY OF WORCESTER BUREAU OF SEWERS 20 E. WARC. ST.
Name _____ St. & No. _____ City/Town State Tel. No. _____

2. _____
Name _____ St. & No. _____ City/Town State Tel. No. _____

3. _____
Name _____ St. & No. _____ City/Town State Tel. No. _____

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Names: _____ St. & No.: _____

City/Town: _____ State: _____ Tel.No.: _____

4. No. of Pictures taken NONE

5. Degree of Hazard: (if dam should fail completely)*

1. Minor ✓ 2. Moderate _____

3. Severe _____ 4. Disastrous _____

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic _____ Manual _____

NONE Operative _____ yes; _____ No.

Comments:

7. Upstream Face of Dam: Conditions:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

onComments:

8. Downstream Face of Dam:

Condition: 1. Good ✓ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____

Comments: _____

9. Emergency Spillway: NONE

Condition: 1. Good _____ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____

Comments: _____

10. Water Level at time of inspection: 2.5 ft. above _____ below ✓
top of dam ✓ principal spillway _____
other _____

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment NONE
Animal Burrows and Washouts NONE
Damage to slopes or top of dam NONE
Cracked or Damaged Masonry NONE
Evidence of Seepage NONE
Evidence of Piping NONE
Erosion NONE
Leaks NO
Trash and/or debris impeding flow YES (IN SPILLWAY)
Clogged or blocked spillway YES
Other _____

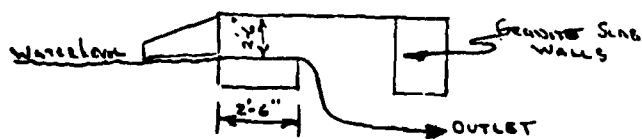
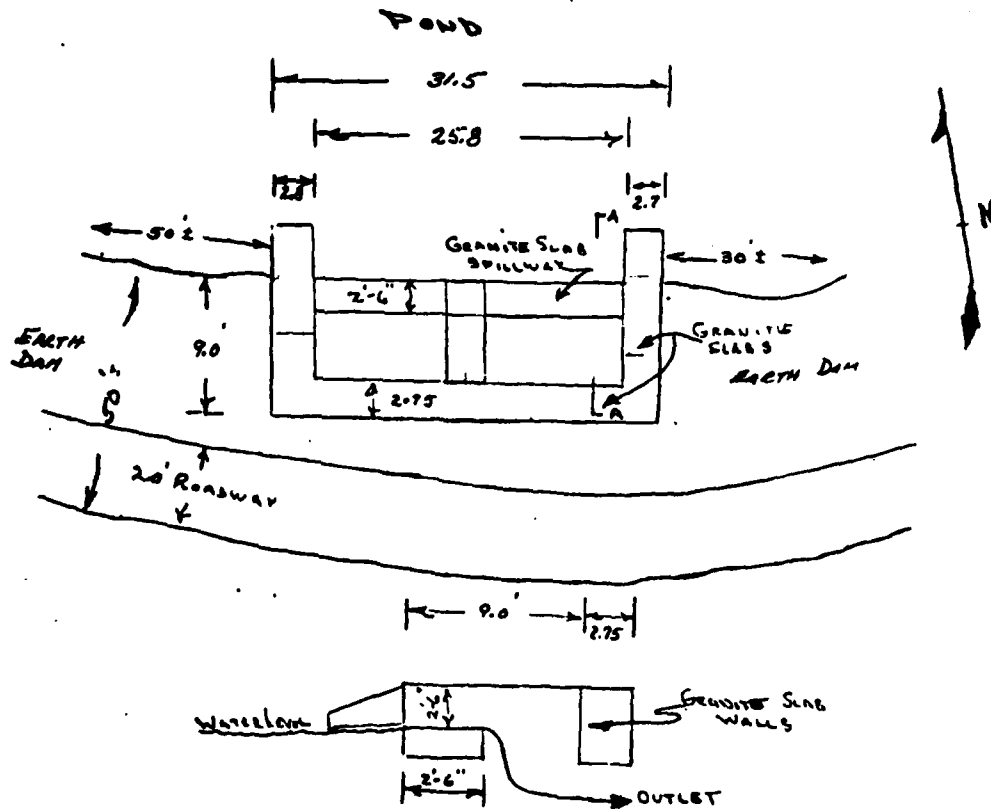
12. Remarks & Recommendations: (Fully Explain)

*THE OVERALL CONDITION OF THIS DAM APPEARS TO BE
VERY GOOD. IT IS RECOMMENDED THAT THE SPILLWAY
BE CLEARED OF ALL DEBRIS.*

13. Overall Conditions:

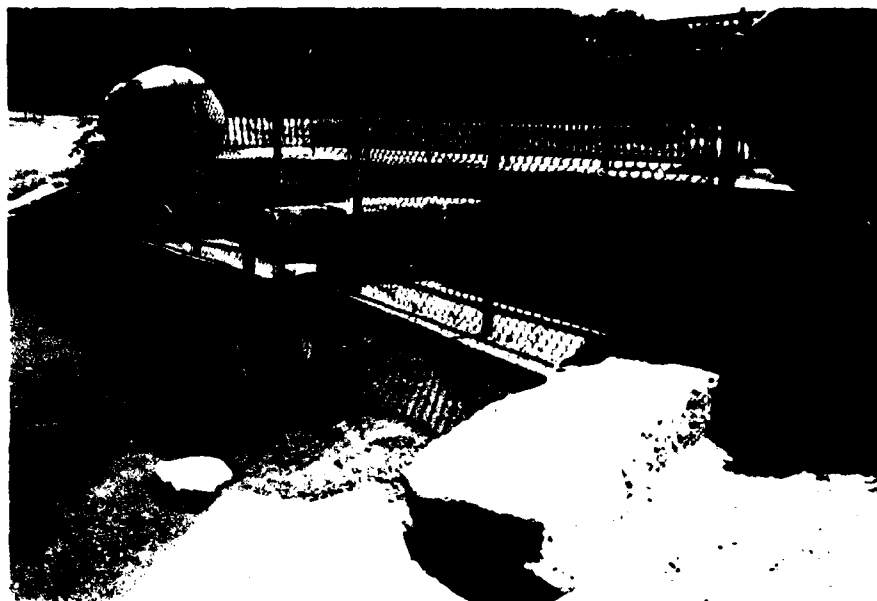
1. Safe ☒ _____
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____

WORCESTER
GREEN HILL POND DAM
DAM No. 3-14-348-23



SECTION 9-A

APPENDIX C
PHOTOGRAPHS



NO. 1 VIEW OF SPILLWAY



NO. 2 VIEW OF DEBRIS IN SPILLWAY



NO. 3 VIEW OF DOWNSTREAM DAM SLOPE



NO. 4 VIEW OF OUTLET CONDUIT

[illegible]

Project Nat. Review of Non Fed. Dams Acct. No. 5864 Page 1 of
 Subject Worcester Mass. Area Comptd. By LEB Date 7/21/78
 Detail GREEN HILL POND DAM Ckd. By RW Date 8/15/78

I Peak Inflow Test Flood & 100 Year Flood

Area of Drainage Area - 0.21 mi^2
 Area of Pond 0.05 mi^2
 No other ponds or swamps in D.A.

Drain Area is 23.8% Pond

$$\text{Typ. Slope } \#1 = \frac{771-651}{900} = 13.3\%$$

$$\text{Typ Slope } \#2 = \frac{751-651}{1200} = 8.3\%$$

Say Average Slope = 11%

From Extended CofE. Plot for MPF-PFR, use point about 25% of dist. below "Rolling" toward "Leesville"

$$\text{P.F.R.} = 2650 \text{ cfs/mi}^2$$

For Low Dam:

$$\boxed{\text{Inflow Test Flood} = \frac{1}{2}(2650)(0.21) = 280 \text{ c.f.s.}}$$

$$\begin{aligned} \underline{100 \text{ yr. flood}} - \text{Chr. rain} &= 4.7 \text{ inches} \\ \text{infiltration} &= 6(0.18) = 1.1 \text{ inches} \end{aligned}$$

$$\left(\frac{4.7-1.1}{19-1.1} \right) (560) = 113 \text{ cfs} = \underline{100 \text{ yr. Flood Peak}}$$

II Storage Functions

$$\text{Inflow Test Flood: } Q_F = 280 \left(1 - \frac{S_F}{9.5} \right)$$

$$\therefore Q = 280 - 29.5 S_F = F_{TF}$$

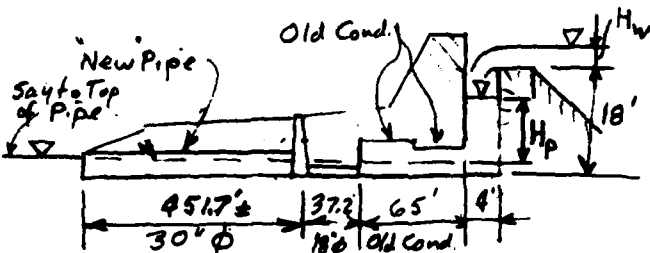
$$\text{100 Year Flood: } Q_F = 113 \left(1 - \frac{S_F}{4.7} \right)$$

$$\therefore Q = 113 - 24 S = F_{100}$$

S = Depth in inches on watershed related to storage on pond.; D = Pond Stor Depth in Feet

$$S = 12(D) \frac{.05}{.21} = 2.86 D$$

(III) Discharge, Storage & Value of Storage Functions



Old Conduit varies from 10 ft² to 30 ft². For this calc, assume old cond has trivial hydr. loss

30" ϕ - $A = 4.91 \text{ ft}^2$; 18" ϕ - $A = 1.767 \text{ ft}^2$; $R_{30}^{2/3} = .73$; $R_{18}^{2/3} = .52$

A - Pipe Flow Relation for H_p

$V_{30}^2 = 0.1295 V_{18}^2 \approx 0.13 V_{18}^2$ Say $n = .013$ for Pipe

$H_p = 1.0 h_{V_{30}} + \frac{V_{30}^2 L}{2g} \left[\frac{.013}{1.49(.73)} \right]^2 + (h_{V_{18}} - h_{V_{30}}) + \frac{V_{18}^2 L}{2g} \left[\frac{.013}{1.49(.52)} \right]^2 + h_{V_{18}}$

$H_p = V_{18}^2 \left[.00202 + .00839 + .01350 + 0.01047 + .01553 \right] = 0.04991 V_{18}^2$

$V_{18}^2 = \frac{Q_p^2}{A_{18}^2} = \frac{Q_p^2}{3.122}$, \therefore $H_p = 0.016 Q_{p,pe}^2$ or $Q_p = 7.9 H_p^{1/2}$

$H_p = (\text{Water Level in Ent. or in Pond}) - 635.5$; Max H_p before Crest Flow = $653.5 - 635.5$

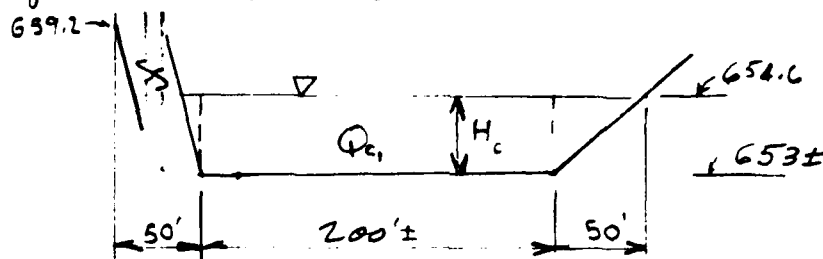
Water Eleu:	651	652	653	653.5	654	654.5	655
H_p	15.5	16.5	17.5	18	18.5	19	19.5
Q_p cfs	31	32	33	33.5	34	34.5	35

B - Weir flow - for 2.5' broad crest & correction factors & sharp edged weir q_c from "Hydraulic Tables" by William & Hazen
 $L = 24' - 0.1(4) H_w$; $p = 6'$

H_w	0.5'	1.0'	1.5'	2.0'	2.5'	3.0'	← Pond El. = 651.0 + H_w
Corr. Factor	0.90	0.81	0.84	0.88	0.92	0.95	
S.E. q_c	1.21	3.36	6.20	9.62	13.59	18.06	
L	23.8	23.6	23.9	23.2	23.5	22.8	
Q_w	23	64	124	196	294	391	
H_p for Q_w	1.3'	10.0'	37.5'	93.7'	210.9'	373'	
$S(D=H_w)$	1.43	2.86	4.29	5.72	7.15	8.58	
F_{TF}	238	196	154	111	69	27	
F_{low}	79	44	10				

C - Crest Flow

Low Pt of "Crest" = 652.5'±, but use 653 as ave. low section
 width of Crest @ El. 660 is 440'±



For Broad Crest assume $q = 2.55 H_c^{3/2}$

$Q_c = 510 H_c^{1.5}$ - ignore sides beyond 200'± since depth will be low

H_c	0.2'	0.4'	0.6'	0.8'	1.0'	0.5'
Q_c	96	129	237	365	510	180

IV Summary of Results (See Item VII)

A. Inflow Test Flood = 280 c.f.s.

Peak Outflow = 92 c.f.s. w/ Pond El. 653.2

Max Depth on Crest = 653.2 - 652.5 = 0.7'; Max $q = 1.5$ cfs/ft

Critical Depth = $y_c = \left(\frac{(1.5)^2}{g} \right)^{1/3} = 0.4'$, $V_c = 3.6$ fps

B. Inflow 100 Year Storm = 113 cfs.

Peak Outflow = 32 cfs. w/ Pond El. 652.2

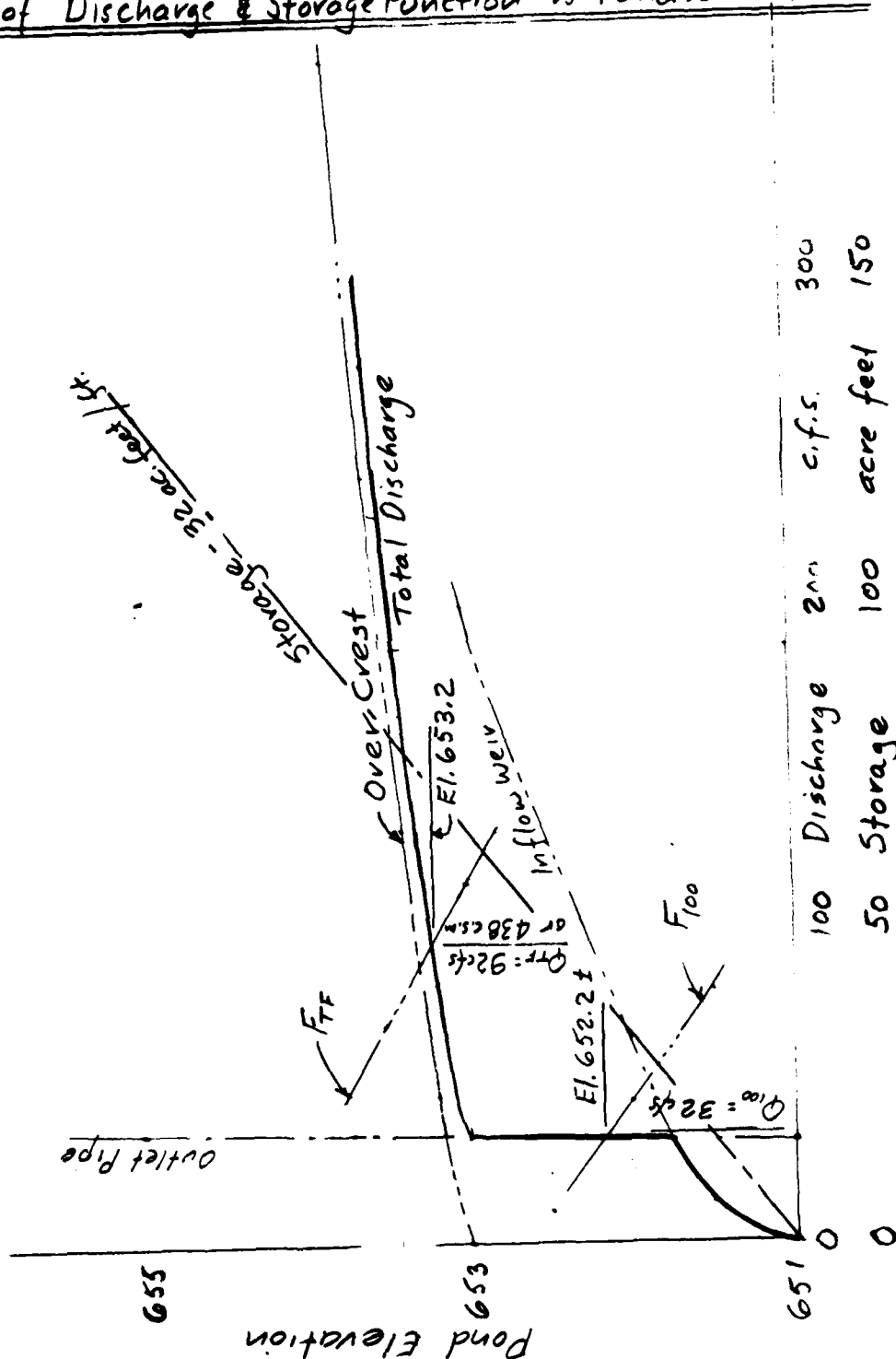
No Flow Over Crest.

C. Max. Disch. before flow over crest = 33.4 c.f.s.
 This is 36% of Test Flood Outflow.

Note: A potential outlet occurs in the northeast end of Green Hill Pond. However, during peak storm flows this outlet would be an inlet, diverting flow to the pond from a street drainage system. Since the diverted area appears small, the effects of this outlet-inlet have been ignored in these calculations.

Project Nat. Review of Non-Fed. Dams Acct. No. 5864 Page 4 of
 Subject Worcester, Mass. Area Comptd By LEB Date 8/4/78
 Detail GREEN HILL POND DAM Ck'd. By RW Date 9/16/78

⑤ Plot of Discharge & Storage Function vs Pond Elevation



METCALF & EDDY, ENGINEERS

Project Nat. Review of Non-Fed Dams

Acct. No. 5864

Page 5 of

Subject Worcester Mass Area

Comptd. By LEB

Date 8/22/78

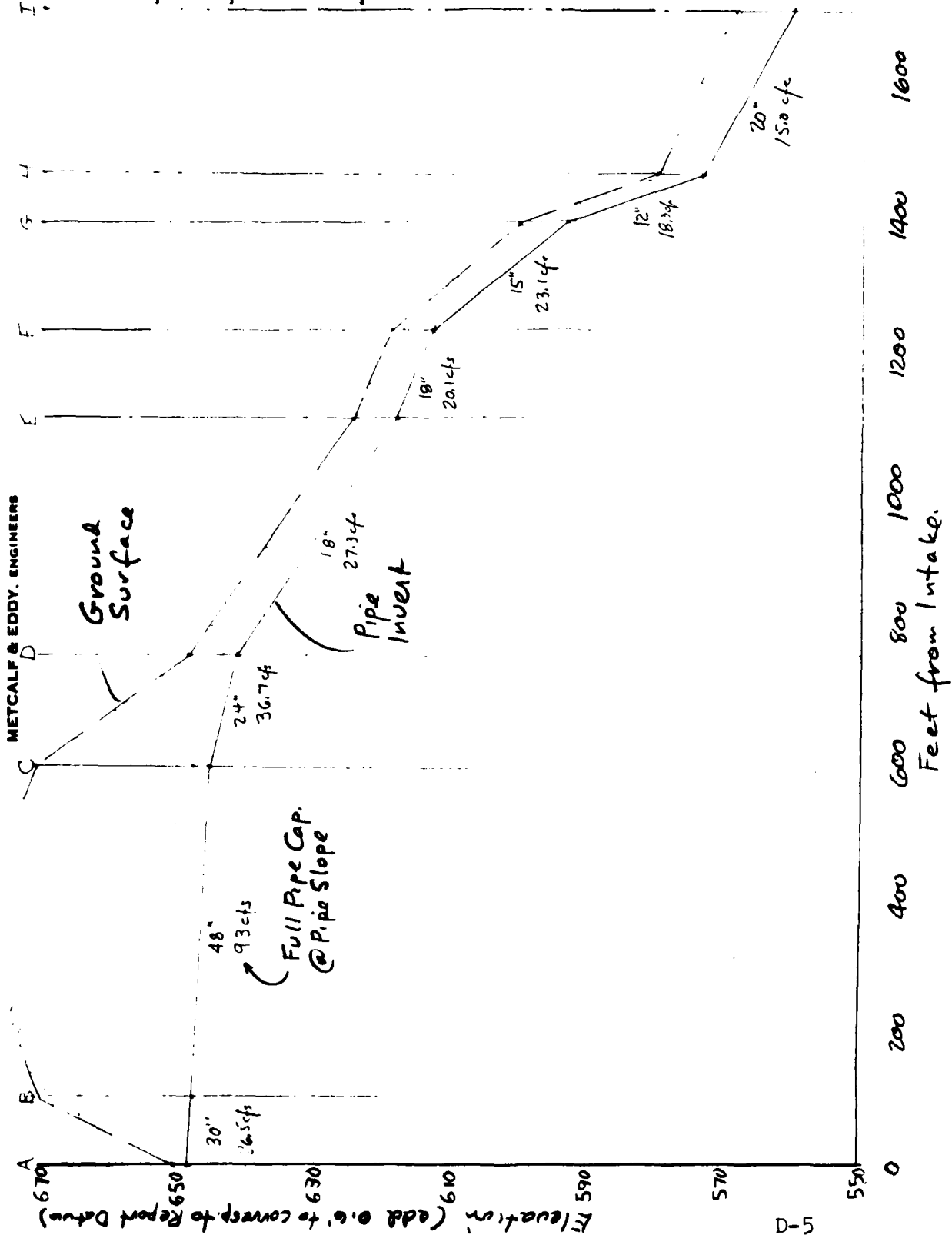
Detail GREEN HILL POND

Ckd. By

Date

(VI)

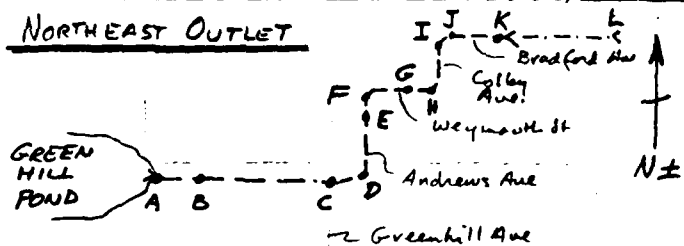
NORTH EAST OUTLET
Profile of Disch. Pipe to Coal Mine Br.



Project Nat. Review of Non-Fed. Dams Acct No. 5864 Page 6 of 7
 Subject Worcester Mass Area Comptd By LEB Date 8/22/78
 Detail GREEN HILL RES. Chd. By _____ Date _____

(VI)

NORTHEAST OUTLET



Note: Bradford Ave appears removed due to constr. of I-290. Assume Sect J-K remains but K-L gone. Elev. shown here are 0.6' ± lower in value than used in Report.

METCALF & EDDY, ENGINEERS

Sect.	Size	Invert @ Entr.	Length	Slope	"Full Q" (n=.013)	Ground Elev. @ Entr.
A-B	30"	648.32	100'	.00417	26.5 ft	650.3
B-C	48"	(647.90)	487.5	.00417	93.0	671.6
C-D	24"	645.87	163.0	.0262	36.7	670.7
D-E	18"	641.60	349.5	.06752	27.3	648.6
E-F	18"	618.0	128.0	.0367	20.1	624.3
F-G	15"	613.3	157.0	0.1274	23.1	618.8
G-H	12"	593.3	76.0	0.2632	18.3	600.0
H-I	20"	573.3	239.9	0.0554	15.0	580.2
I-J	20"	560.?	36	0.05	14.3	566.7
J-K	20"	558.2	162	.03189	11.4	565.4
K-L	20"	(553.0)	393	.03189	11.4	558 ±
End	-	540.5				543 ±

The Northeast Outlet connects the pond to a street drainage system which normally runs to Coal Mine Brook. The connection to Green Hill Pond would allow the pond to act as a temporary storm water detention basin & relieve the impact of high flow on the street drainage system. The area with drainage diverted to the pond appears minor and may be included in the estimated drainage area. This outlet would not function during peak flows - but would aid in drawing down flood storage after the peak inflow had past. A proper analysis of this "outlet" does not appear warranted or important for this Phase I Report.

AD-A146 268

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
GREEN HILL POND DAM ((U)) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV AUG 78

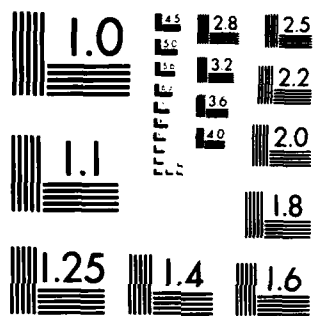
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UNCLASSIFIED

F/G 13/13

NL

END
DATE
FILMED
10 84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

VII Dam Failure

Crest Elev. - 651 ±

Toe Elev. 640 ±

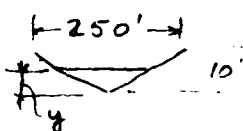
$$y_0 = 11'$$

Length Subject to Potential Failure = 120' ±

$$Q_p = 120(.4)1.68(11)^{1.5} = 2940 \text{ cfs}$$

Vol. Stored below Crest. -

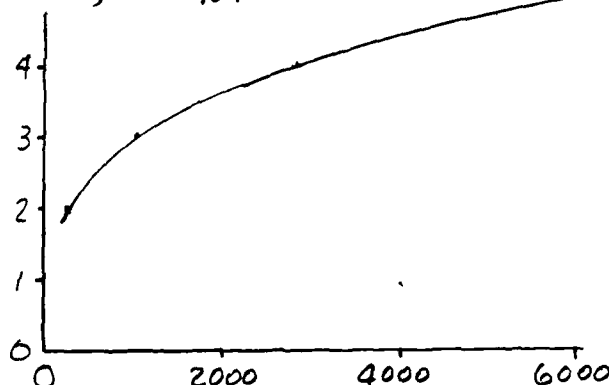
$$(\text{Est}) V_s = \frac{1}{3}(11')(0.05)(640) = 117 \text{ acre feet}$$



$$A = 12.5 y^2; P \approx 25y; R = \frac{y}{2}; n = .04$$

$$S = \frac{20}{1100} = .0182, V_e = \frac{1.49}{.04} R^{1/3} (.0182)^{1/2} = 5 R^{2/3}$$

y	A	R ^{1/3}	V	Q
2	50	1	5	250
3	112.5	1.84	9.2	1033
4	200	2.83	14.1	2828
5	312.5	3.95	19.8	6176



1st Reach: 1500' to 1st Structure; $Q_p = 2940$, $y_1 = 4'$, $A_1 = 200 \text{ ft}^2$

$V_1 = 200 \times 1500 = 6.9 \text{ acre ft.}$; $V_1 < 10\% V_s$; Use Full Q_p

At 1st Structure: Flood Wave a Max. of 4' deep, traveling at 14 ± fps.

APPENDIX E
INVENTORY FORMS